Lean Principles Implementation in the Program Preparation Phase

by

Freddie Douglas, III

Master of Science in Engineering
University of Alabama in Huntsville, 1989

Bachelor of Science in Mechanical Engineering
Southern University and A&M College, 1983

SUBMITTED TO THE SYSTEM DESIGN AND MANAGEMENT PROGRAM IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN ENGINEERING AND BUSINESS MANAGEMENT

AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

FEBRUARY 2002

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ABSTRACT

The space launch system framework brings to the forefront the implications of multiple stakeholders, market conditions, the convoluted manner in which public sector programs are conceived and implemented, and the perceived smoother and focused manner for private sector efforts. In the public sector case this process is drawn out and typically, the financing structure does not support obtaining the overall best costs. The inter-relationship of demands, brought by various stakeholders serviced by the Public Sector, result in reinforcing behavioral loops that make it virtually impossible to satisfy the needs of the Public Sector enough to ensure global competitiveness for the private sector. The public sector has taken steps to ensure that regulatory and infrastructure capabilities are competitive enablers. In addition, the Public Sector also focuses on reducing the cost-per-pound-to-orbit as a measure of competitive effectiveness or advantage. However, the appropriateness of this measure changes as the customer/supplier relationship changes from Public Sector, to launch service provider, to satellite developer, to the General Public. Measures for these relationships move from cost-per-pound-to-orbit, to providing assurances of affordability, profitability, reliability, capability, and availability to maximizing benefit from a multi-billion dollar revenue stream.

In the program/project Preparation Phase, these measures manifest themselves in terms of implementation strategies based on market conditions and timing. Lean focuses on value from the customer's perspective; for this work, its definition is hypothesized to be service oriented and embodies service management features of tangible and intangible elements. Leveraging this definition, service embodies the act, perceived quality and cost to the customer: the same attributes that epitomize the amorphous and dynamic formulation environment associated with the Preparation Phase. This hypothesized expression of value is verified through case study of cancelled launch vehicle programs, analysis of system performance parameters that drive launch system costs, congressional records, interviews with industry participants, surveys and other artifacts from other industries that develop complex systems (i.e., shipbuilding, offshore exploration and cargo aircraft).

Major hindrances to successful integration of public and private goals and objectives in complex systems, like launch vehicle development, is the high cost of the technology involved and return on investment considerations. In both cases, methods of funding and the recovery of expenses are important.

Yet, the methods used are not necessarily compatible. The year-to-year cash flow basis of funding and related uncertainty resulting from the political process, does not support gains from economies of scale and the heightening of the possibility of reneging on agreements. These issues are extremely important in today's environment where Private Sector participation in Public Sector-sponsored activities include shared risk and costs. Other considerations that cause inefficiencies in the development process that are carryovers from the preparation stage, are market dynamics, size and the organizational structure used during the development (this is of particular importance when the customer/supplier relationship is public-to-private). Interviews with Private Sector developers indicate that payload-to-orbit-costs and reductions in facility operations costs, are important and should be monitored. However, they are dwarfed by opportunity costs associated with market timeliness and revenue streams for the payload owner.

In the Preparation Phase of Programs/Projects, Lean Principles can be applied to a variety of assurances and process methodologies. These principles are used in conjunction with service management principles that help to identify task and process importance to the overall customer value. An example of customer value would be early recognition of the potential incompatibility of the goals and objectives of the parties involved and subsequently work to minimize the long-term implications of this condition. This scenario is an example of Muda in the formulation process. Without incentives for both parties to participate, the program would not be executed. Compromises are necessary on the part of both parties to see the program executed (this is a form of necessary waste or Muda). Another would be recognizing that platform architecture issues are important and should drive timing between derivative products and the infusion/leveraging of technology. Since public and private investment strategies have not supported continuity in launch system technologies, significant gaps in the knowledge spectrum exist and require sizeable relearning of technologies and systems performance behaviors. Other areas where this exists includes continuity of leadership and a heightened potential of reneging, which are interface issues at the point-of-service delivery. These are perceived to be highly important. The Servuction framework highlights these measures of effectiveness, held important by one party, which are not necessarily important by the ultimate end customer providing the end service. This is manifested by the Public Sector's continued focus on reducing launch service costs. However, when considering the total system cost and performance, launch services are a small part of the costs. Degree of importance from the end customer perspective is the reliability and availability of such systems and associated facilities and qualified personnel. This is also an unrecognized goal of the Public Sector in its efforts to support economic competitiveness for US industries in the commercialization of space. This is also an example where waste in the development process exists due to misalignment of performance measure structure and importance. This form of waste has to be eliminated and the proper alignment achieved.

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ACKNOWLEDGEMENTS

To NASA, for affording me the opportunity to study at the seat of modern engineering thought—MIT.

To my parents: without your love, encouragement, and sacrifice, none of this experience would have been possible, thank you so much for the gift of a lifetime.

To my children, Candace, Morgan, and Lacey: I thank each of you for your love and encouragement, but especially for the unique opportunity to sit around the table and do home work together. It is said that children learn by example. It is my hope and prayer that each of you learns from my example and knows that all things are possible when Christ is in your life. [Philippians 4:13]

To my wife Anita: thank you for your untiring love and support, which made this experience possible, and our relationship stronger.

To my Lord and Savior: I give thanks for this gift and it is my prayer that it is used for your glory and the edification of your children. [1 Corinthians 12:1-11]

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Chapter 1 - Introduction

1.1. Thesis Goal

The development of complex systems is achieved through the execution of a Lifecycle which consist of Program/Project (P/P)[1] phases: 1) preparation, 2) planning, 3) execution, 4) adaptation and 5) disposal. [1] These phases provide a framework for managing and conducting the development effort associated with these systems. The goal of this thesis is to demonstrate the customer/supplier relationship during the Preparation Phase more closely follows that defined by the field of Management of Services.[2] This methodology and heuristic is believed to be consistent with the application of Lean Thinking and Principles.

The Preparation Phase is critical to the long-term success of any P/P undertaken. It is during this phase that goals, objectives, and the manner in which the P/P will be executed are established. This is especially true when the systems are sizable, complex and proceed over long periods that include the influences of political and market dynamic effects. This thesis uses the United States' (U.S.) efforts to develop cost effective access-to-space systems, as a case study to test this heuristic.

1.2. Motivation: Access-to-Space

Man has dreamed of space exploration, traveling to the outer reaches of the universe, in search of other life forms. Post World War II, the imagination turned to low earth orbits and the impact rocketry could have as a military weapon, but equally as a means of improving life here on earth. As we all know, the space race of the 50's and 60's led to the U.S. embarking on the awesome task of sending and returning a man to the moon. As the Saturn program matured, plans were developed that included the development of a reusable launch vehicle and space station, both of which would be manned. The end of the Saturn program saw the launch system offered to the Private Sector as an opportunity for profit. [2]

[1] Program development or project development are terms used within complex system development circles and are similar in nature. However, the major difference is the magnitude and scope of the effort.
[2] Services is defined as the act, performance, process, and benefit that does not result in the customer owning anything. [9]

Following the Saturn program, the U.S. embarked on the National Space Transportation System (NSTS), e.g., the Space Shuttle, in an effort to consolidate and focus space policy with respect to development and operational costs, through the use of a partially Reusable Launch Vehicle (RLV). This also included Expendable Launch Vehicle (ELV) systems, which were defense focused. At this time, the U.S. had a dominant position in the world market for ELV services. These services included robotic science and exploration missions, as well as those focused on unmanned national security.

However, policy consolidation and the development of the NSTS resulted in a reduction in Research and Development (R&D) expenditures for expendable launch systems development. [3] The manifestation of the policy directs the use of the NSTS as the primary launch system for Civil and Department of Defense (DoD) missions. Coupling this with the 1986 loss of Shuttle flight 51-L[3], the U.S. saw its dominance in the ELV market significantly eroded. To recover, the U.S. re-invested in ELV systems and began pursing RLV's that could achieve performance targets not reached by the development of the NSTS.

The pursuit of these performance parameters has seen the initiation and cancellation of approximately eight (8) of twelve (12) Launch Vehicle efforts. Figure 1 is a pictorial representation of the systems and their relative time of initiation and cancellation. The systems considered are the NSTS, National and Advanced Launch Systems, National Aerospace Plane (NASP), Advanced Solid Rocket Motor (ASRM), Evolved Expendable Launch Vehicle (EELV), DC-X, X-33, X-34, X-40, and X-37. Each of these systems has some portion of its take-off mass that is not recoverable once the launch mission profile is completed. Of the systems considered, all but NSTS, EELV, X-40, and X-37 have been cancelled for a variety of reasons. [4]

Some say affordable and reliable access-to-space can only be achieved through the development and operational deployment of a single stage to orbit vehicle. The current fleet of vehicles is either completely or partially expendable vehicles. A significant technological gap exists between the current

[3] 51-L is the flight designation of the Space Shuttle Challenger flight that exploded during ascent on a January 1986 launch.

access-to-space technology and that required to achieve single stage-to-orbit capability and the desired performance metric. Considering the efforts to develop an access-to-space system and the complicated nature of its process interactions, the question becomes why were these development efforts terminated during the early phases of the development lifecycle. A contributing factor is the multitude of organizations with cognizance over various aspects of the systems' lifecycle. This is further complicated when, in recent years, commercialization implications were added. The nomenclature for the Preparation Phase, in NASA terms, is known as Pre-Phase A/Phase A, Concept Development. For the DoD, it is known as Pre-Milestone A/Milestone A, Pre-System Acquisition. [5, 6] Therefore, how is value determined for these complex systems from the vantage point of their respective organizations?

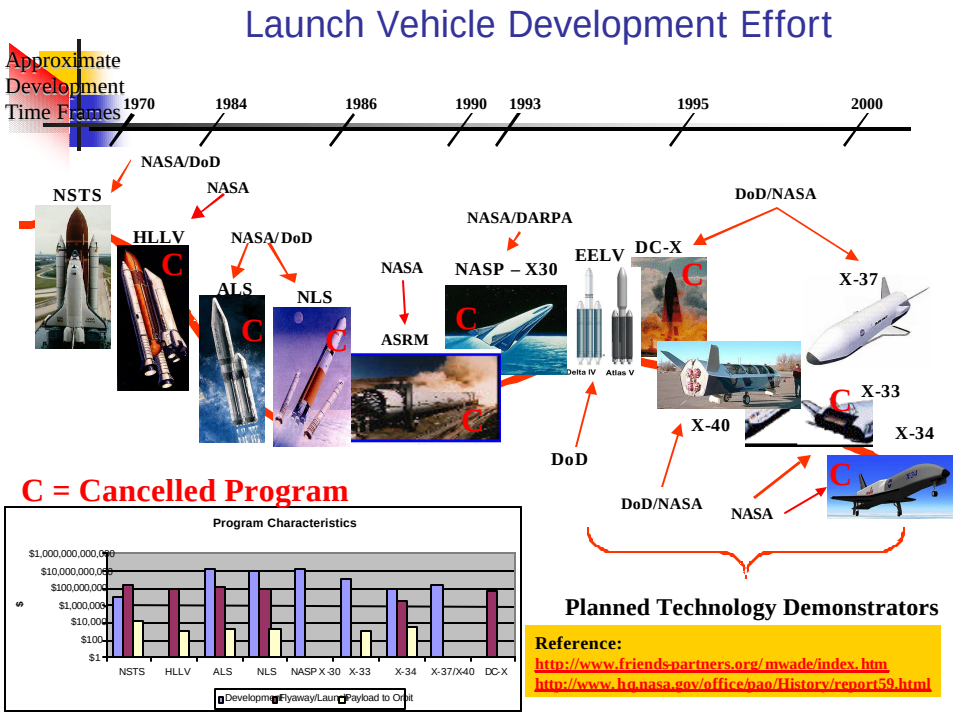

Figure 1 - Access-to-space Launch System Development Efforts

Studies have identified characteristics and Measures of Effectiveness (MOE) that describe Lean Thinking and Principles as applied during the production and design and development phases. It is not obvious that these principles can be extrapolated to the P/P Preparation Phase because of the intangible nature of the products resulting from this stage.

The commercial launch services market contains decisions surrounding value to multiple stakeholders across the entire development lifecycle. An example would be the decision to commercialize the Space Shuttle. The system was not developed with this goal in mind and its development included trade-offs where long-term operational cost reducing efforts were eliminated in order to reduce near term annual capital outlay. When conditions changed and commercialization is the "buzz," wonderment sets in when the commercialization effort does not generate the desired results. In addition, licensing overhead, facility operations, and global competition all led to mismatches in market timing, technology, "ilities" (availability, reliability, capability, affordability), decision-making, and public support. This results in increased opportunity for discontinuity in goals/objectives and MOE for determining success.

1.3. Problem Statement

Developing complex systems, especially when the Public Sector is the end user, has a number of influences that all contribute to the difficulty and uncertainty that is typically attributable to this situation. The cancelled access-to-space programs are an example of the casualties associated with the system dynamics in developing complex systems for Public Sector benefit. The causal loop diagram (Figure 2) depicts the relationships between the influencing factors, all of which contribute to the goals of minimizing System Development Cost & Schedule, the desired goal to reduce payload-cost-to-orbit and the technology needed to depart from the1950/1960 expendable vehicle architecture.

Figure 2 has a combination of positive reinforcing loops and negative balancing loops. These loops are the mechanisms through which the push and pull of the influence factors are imparted on system elements. The "+" sign at the end of a loop indicates a continuing increasing effect from one system element to the next. A " – " sign indicates an inverse relationship, as one system element increases the following decreases. The inner main loop addresses the influences of architectural change upon the cost of technology development, of technology development costs on overall system development cost and schedule and finally on payload-cost-to-orbit. Outer loops include the influences of strategies from the

customers and suppliers perspectives. Other minor loops show influences of Academia on the System Development cost, schedule, and the need for profit by the Private Sector and its influence on payload-cost-to-orbit. [7]

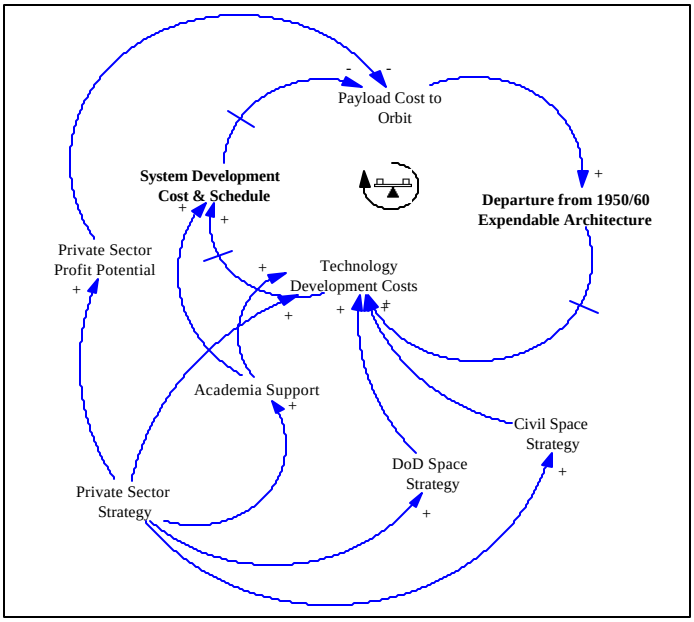

Figure 2 - Strategy Integration and Development Causal Loop Diagram

The degree to which access-to-space architectures depart from expendable concepts results in a corresponding increase in expected technology development. The influence of Architectural Departure on Technology Development Costs, has an inherent time delay. This delay can be attributed to the effort required to achieve the Architectural Departure and the accrual of effort associated with the Technology Development itself. Time delays are also associated with the relationship between Technology Development costs and System Development Cost and Schedule. Time delays are finally associated with the influence of System Development Cost and Schedule on Payload-cost-to-orbit.

1.4. Applicable Models

There are indications that optimal value capture is achieved when holistic consideration is given to the entire lifecycle. Best Lifecycle Value (BLV)[4] integrates multiple perspectives of value by bringing together system engineering, value analysis, and lifecycle costing. This integration has resulted in a theoretical framework for managing Value Identification and Delivery that optimizes the Value Proposition. This proposition spans the entire development cycle through balancing stakeholder expectations against system performance (perceived and factual).

As Figure 3 reflects, Value Identification associates with identifying the stakeholders and understanding each of their respective value systems and establishing their expectations. Value Proposition associates with the alignment of multiple stakeholder values and balancing their respective expectations and contributions to the effort. Value delivery creates a system that implements the proposition consistent with balanced expectations across the entire lifecycle. This process is not a one-time effort but is influenced by system dynamic interactions from external and internal interactions, both forwards and backwards, along the lifecycle. The attributes of the BLV, as defined by Stanke, are Holistic Perspective, Organizational Factors, Requirements and Metrics, Tools and Methods, Enterprise Relationships, and Leadership and Management. [8]

[4] The application of BLV, as used in this thesis, is an extension of an existing body of research conducted by the Lean Aerospace Initiative.

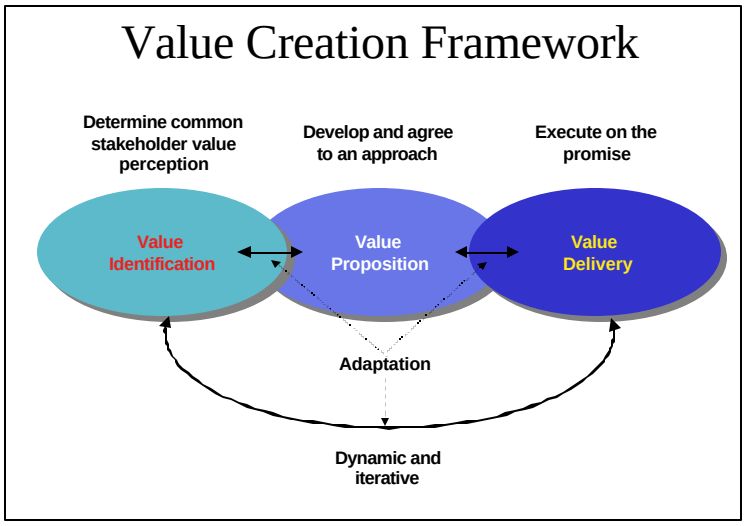

Figure 3 - Value Creation Framework (adopted from [8])

1.4.1. Program/Project Management

The development of complex systems is not an over night proposition. Great care and consideration is required not only for the complex technical systems, but also for the corresponding organizational and interpersonal issues. The P/P lifecycle is the collection of related steps that systemically offer a means of capturing value by developing a product or process. The phases of development will vary slightly by implementing organization. Examples of such are the versions presented by the National Aeronautics and Space Administration (NASA) Policy Guide 7120.5A, Program and Project Management Process and Requirements. This is also covered in the NASA System Engineering Handbook and the DoD Project Managers Toolkit. For the purposes of this thesis, simplification of these processes is necessary. The associated detail is typically organizational specific. Figure 4 represents the elements and their relationship to one another. The P/P phases are defined as Preparation, Planning, Execution, and Adaptation phases.

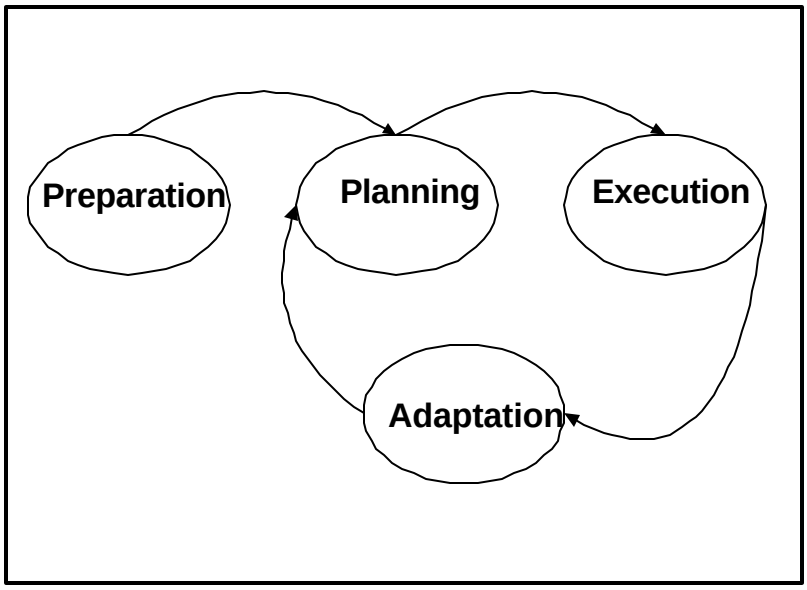

Figure 4 - Program/Project Development Lifecycle (adopted from [1])

The details of each phase are critical in determining stakeholder value over the duration of the development cycles. It also is reflective of the issues that must be considered and managed during each phase. Table 1 defines the underpinning characteristics of each phase of the lifecycle. Not explicitly stated in this model is the need to end or dispose of its artifacts. In some vernaculars, disposal is considered a part of the Execution Phase.

Table 1 - Program/Project Development Lifecycle (adopted from [1])

Development Lifecycle Phase	Characteristics
Preparation	• Define Scope • Identify Users • Obtain Resources • Review Previous Efforts • Select Collaborative Tools • Identify Standards
Planning	• Define Performance Requirements • Define Deliverables • Define Communication Structure • Select the process Model • Define Distributed Teams Boundaries and Responsibilities • Identify Basic Activities • Estimate Effort for Activity • Allocate Resources • Define Measurables

	• Create WBS and Schedule • Identify Risks and Schedule • Prepare the Management Plan • Define Reward Structure
Execution	• Perform Monitoring • Perform Control • Perform Quality Assurance • Create Lesson Learned Log
Adaptation	• Respond to Emerging Issues • Mitigate Emerging Risks • Communicate Changes • Update Management Plan

1.4.2. Management Issues

P/P Management is a strategic organizational capability that is critical to success or failure of any organized body engaged in efforts defined by specific scope, time and cost. Recent developments have focused on the product integration in both the vertical and horizontal axes. The vertical realm has seen development organizations foster closer relationships with their down stream customers and upstream suppliers. Horizontally, development organizations have integrated functional and administrative organizations to pull needed capability (core competencies) closer to the development activity. In addition to these, it is critically important that an organization consciously design the delivery of derivative products or services into the market that leverages its technological advancements.

The design and delivery of services falls within the Management Science area of Management of Services. In this area, frameworks for service delivery are used to design systems and develop understanding of the uncertainties in providing a service. The Servuction and Servqual models are used to address the interaction between the customer and supplier during the P/P Phase.

1.4.3. Service Management Models

Service is "Any act, performance, process, or benefit, that does not result in the customer owning anything." [9] Management of Services is a complex interaction of behaviors centered on the rational and irrational behaviors of the customer. Management of Services also includes the fact that the service must satisfy a perceived notion of quality and value to the customer. The notion of not owning anything is an integral part of the product development lifecycle when considering the Preparation stage. The

Management of Services takes on four characteristics that result in value, from the customer's perspective that is subjective and is the result of interpretation, judgment, and perception: Intangibility, Inseparability, Heterogeneity/Variability, and Perishability.

Intangibility addresses the notion that the interaction between the customer and supplier results in the customer receiving a product that is not sensible to human beings, but is an experience. Intangibility is difficult to manage because it is significantly based on perceptions. However, throughout the experience, efforts are made to "tangibilize" the experience such that the abstract nature is reduced. Inseparability describes the customer/supplier interaction where perceptions of quality and value are produced and consumed by the participants. The quality of the interaction determines the degree of satisfaction derived by both parties. Success in executing this interaction comes as a result of experience and investments in employee development. Heterogeneity/Variability describes how the delivery of service, by the supplier, is unique to the individuals involved. Subsequently, the consistency and perception of quality and value will vary with the individual. Perishabililty attempts to account for the fact that the interaction cannot be recreated exactly. Therefore, the supplier must manage any variability in the conditions under which the interaction takes place that is different from the previous experience. [9]

The models used in the area of Management of Services are the Servuction and Servqual Models. The Servuction Model provides a framework for understanding the proposed service and how it will interface with the customer. The Servqual Model provides another framework for understanding the relationship between the customer and the supplier and how the quality of the interaction can be managed by understanding where discontinuities might exist in expectations and perceptions.

1.4.3.1. Servuction Model

The Servuction Model, shown in Figure 5, is related to the Service Profit Chain and accounts for the mechanisms through which desired service is provided. It includes those processes and functions necessary to ensure that system behavior surrounding the service, such as system analyses (i.e., risk, logistics, operations, etc.), employee training and management, financial, and many others should be invisible to the customer. The model also takes into account those attributes the customer does find

valuable when conducting a transaction (e.g., knowledge of the individuals conducting transactions and the conditions under which the transactions occur). [9]

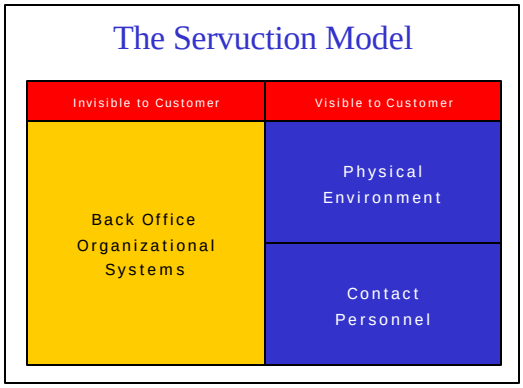

Figure 5 - Servuction Model (adopted from [9])

1.4.3.1.1. Blue Printing

Blue Printing, a subset of the Servuction Model, is a systematic process of understanding the issues surrounding the delivery of services and the opportunity for value generation for the customer and capture by the supplier. Blue Printing, as shown in Figure 6, suggest that consideration be given to individuals' propensity to over simplify the issues and not take due diligence in assessing the capability of the service system to deliver the desired value and an opportunity to capture it. It also encourages the notion of double-checking and sanity checking to assure that critical systems and processes are sufficient to meet desired MOE. These risks can be mitigated by understanding the logistics (support systems), and by effectively applying decision theory supported by computer simulation. [10]

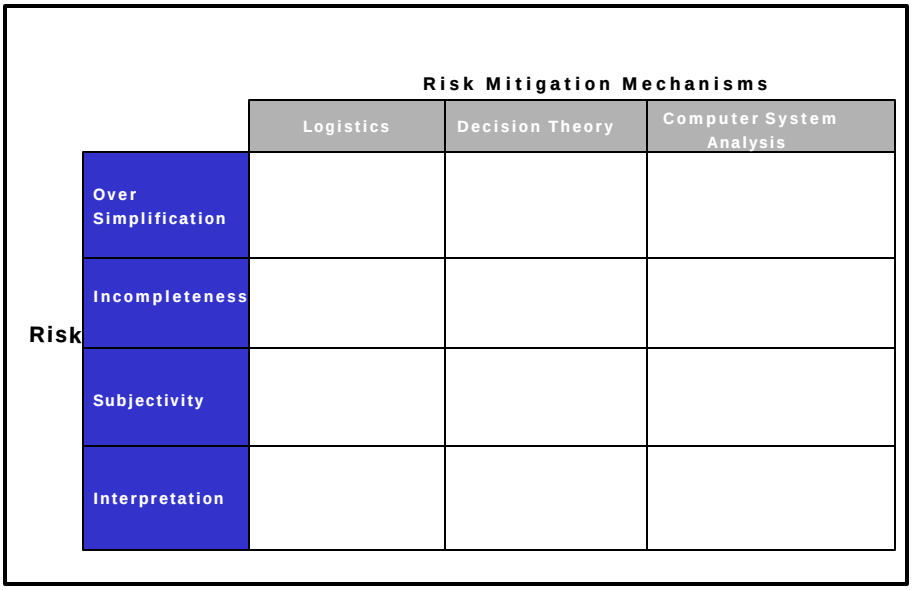

Figure 6 - Blue Printing Analysis Framework [10]

1.4.3.2. Servqual Model

The Servqual Model is a road map for managing the delivery of quality services by understanding the existence of "differences" or "gaps" in the customer/supplier relationship. Figure 7 provides indications of the locations and issues surrounding each of the noted potential gaps in service quality. The gaps are:

- Gap 1 = Market Analysis
- Gap 2 = Design Issues
- Gap 3 = People Issues
- Gap 4 = Misapplying Issue
- Gap 5 = Sum of Gaps 1 – 4.

As noted in Figure 7, these gaps occur on either side of the point of service interface. No matter which side the gap is on, it is of issue to the service provider. The main difference depends on how involved is the customer in either growing or reducing the gap. Gaps occurring on the Supplier (i.e., Supplier) side of the interface are issues that must be resolved transparently to the customer side of the Servuction Model. The others should be engaged openly with the customer, at and beyond the point of Service Execution.

Gaps of importance are those where the discontinuity crosses to the visible from the invisible regions. Figure 7 depicts this as Gap 1 and reflects differences in the perceived quality of the service provided, and the quality and value of the service received as determined by the customer. [11]

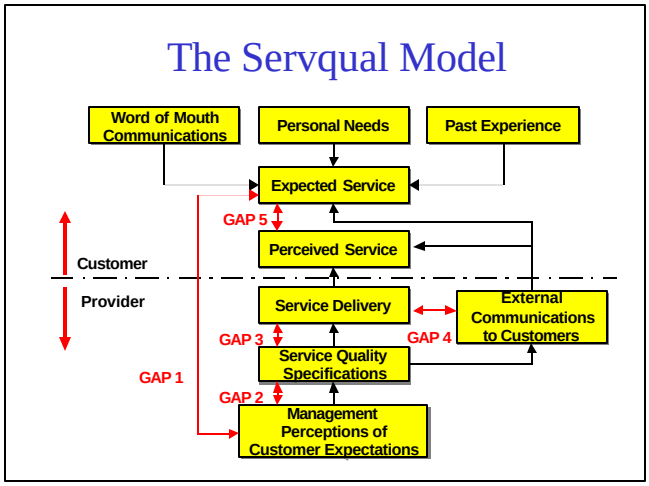

Figure 7 - Servqual Model (adopted from [11])

Initial research indicated that the Servqual Model has ten dimensions that describe the quality and value associated with the service provided. Further research indicated that the ten dimensions could be reduced to five, as reflected in Figure 8. Figure 8 reflects the correlation of the consolidation of the ten dimensions down to five. [11]

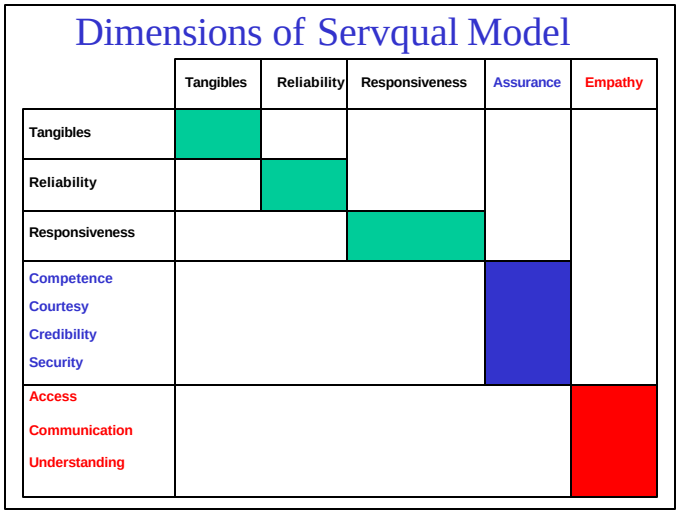

Figure 8 - Servqual Model Dimensions (adopted from [11])

1.4.3.3. Customer Value

In the services world, customer value is expressed using the Service Profit Chain, where value is expressed in terms of the ratio of overall results provided and the associated quality, to the price of the service and any additional costs to acquire the service. This expression is shown in Equation 1. This approach to value provides an opportunity to relate the internal and external costs of a service with the associated quality of the service and the quality of the interaction with the service provider.

$$\text{Customer Value} = \frac{\text{Results Produced for Customer} + \text{Process Quality}}{\text{Price to the Customer} + \text{Cost of Acquiring the Service}}$$

Equation 1 - Customer Value Equation From the Service Profit Chain [12]

1.5. Thesis Outline

The goal of this thesis will address, through a sequence of chapters that detail the development of a heuristic and its relationship to Lean Thinking and Principles. The remaining chapters are as follows:

Chapter 2 – Provides a discussion of the heuristic definition to address P/P Preparation Phase value;

Chapter 3 – Provides a discussion of Lean in the Product Development (PD) Process;

Chapter 4 – Provides a discussion on the U.S. access-to-space capability as a case study;

Chapter 5 – Provides a discussion of the analysis conducted using the data derived from Aerospace Executive Interviews, a review of Congressional Records, and a survey of P/P managers;

Chapter 6 – Provides a discussion of data that validates the goal of this thesis through correlation of value attributes with that of service quality models using system engineering techniques;

Chapter 7 – Addresses potential follow-on research opportunities.

Now that all the models have been introduced, Chapter 2—Heuristic Development and Methodology, will discuss how the integration of the models support the development and testing of the heuristic. Chapter 2 will also identify the engineering and architectural methods that will be used to mature the heuristic through a systemic analysis.

Chapter 2 – Heuristic Development and Methodology

This chapter will develop the concept that the interaction between customer and supplier, during the P/P Preparation Phase of the lifecycle, more closely resembles that associated with the management of services. The concept is further developed to include the notion that the Best Life Cycle Value (BLV) framework for value can represent value, in Lean Thinking and Principles terms, for this phase. The integration comes as a result of the application of the Service Management Models in bridging the "gap" between the BLV value framework and the P/P lifecycle.

2.1. Lean Thinking and Principles

Lean Thinking and Principles provide a guide for the constant pursuit of value for the customer. Lean has its origin in the Toyota Production Process and was brought to the U.S. via a study of the U.S. automotive industry that culminated in a book call the Machine that Changed the World. [13] Womack and Jones congealed the concepts and principles from this book into a book called Lean Thinking. [14] From this book and practice, Lean organizations work to "precisely define value in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers." [15] The all-encompassing effort of Lean practitioners is to understand the customer's needs and to optimize a system that provides for those needs in a way that the customer perceives value to exist. Thus, five principles summarize Lean Thinking and Principles:

- Precisely Specify *Value*
- Identify the *Value Stream*
- Make Value *Flow*
- Let the Customer *Pull* Value
- Pursue *Perfection.*

Considering global competitiveness, a dynamic environment exist where it is imperative that an organization maintain a clear understanding of how it creates value and what opportunities exist that allow it to capture that value. [14]

2.2. Heuristic Development

Lean has been the focus of research that ranges from the manufacturing floor to other dimensions of the product development lifecycle. This migration effort has gone forward to the supply chain, backward into design and development, and laterally into administrative and financial functions of the enterprise. It is believed that the application of Lean, via the BLV approach, takes on characteristics more akin to interactions indicative of the service industry, and is particularly true when considering the early phases of the P/P Management Process. It is during the Preparation Phase that the concept, development approach, strategic planning, and team identification are generated which constitutes the majority of phase products produced by the implementation team. It is important to recognize that during this phase, extreme care should be taken not to underestimate or overestimate the challenges associated with the development effort. Any discontinuities between the customer's expectations and the perceived quality of the service provided can lead quickly to negative consequences. Therefore, this discontinuity or "gap," must be managed as to minimize the opportunity for customer expectations to significantly depart from the perceived qualities of the customer/supplier interactions or services provided. A diagram of this relationship is shown in Figure 9.

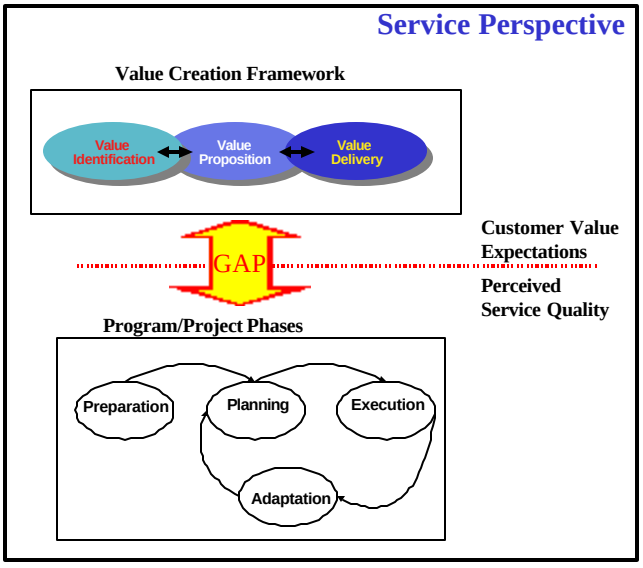

Figure 9 - BLV Framework From A Service Perspective

Furthermore, it is believed that this model possesses properties similar to the mathematical axiom of The Distributive Law of Multiplication over Addition[5]. Figure 10 reflects the property through the decomposition of that shown in Figure 9 and results in equally influential sets of relationships between the BLV Framework and the P/P Management Process elements. Therefore, "gap" management is required for each relationship.

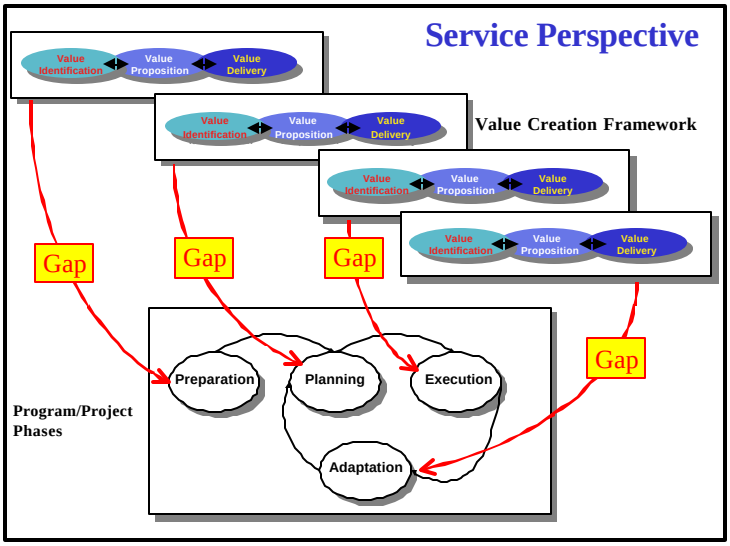

Figure 10 - Distributive Law of Multiplication over Addition Behavior

The lowest level of the decomposition, shown in Figure 11, reflects the notion that the characteristics of the BLV Framework are applicable to each phase of the Program Management Process. It is at this level that this thesis will focus its attention.

[5] For any numbers a, b, and c, a (b + c) = ab + ac.

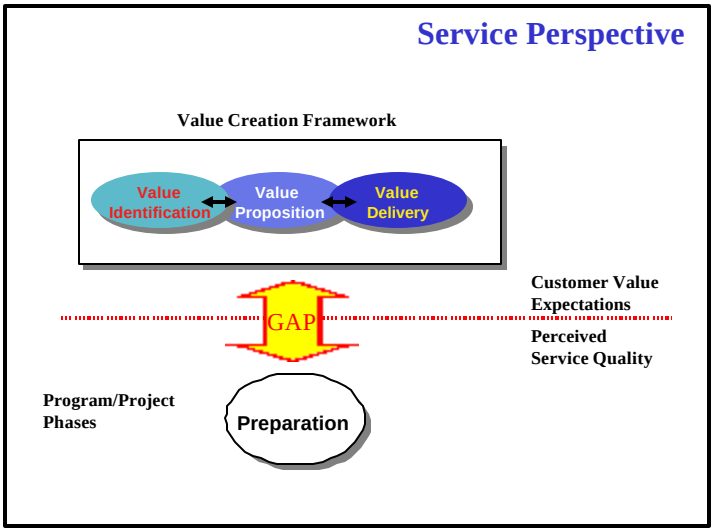

Figure 11 - Lowest Level of Decomposition

2.3. Premise and Feature Statement

The result of this attention will be the formulation of the notion that Lean Thinking and Principles can be extrapolated into the P/P Preparation Phase. This recognizes that products are intangible and highly subjective to customer interpretation. The premise for this condition is stated below along with sub-features (F_n).

The premise is: Value in the P/P Preparation Phase is captured during the interaction between the Customer and the Supplier where the products are primarily intangible. Sub-Features are as follows:

F_1: The characteristics of the BLV are consistent with those of the Servqual Model.

F_2: The characteristics of the Servuction Model are applicable to the P/P Preparation Phase of the management process.

F_3: Value can be expressed in services terms.

2.4. Thesis Methodology

This section describes the methodology and tools used in conducting this research. It addresses the system architecture and system engineering frameworks that are employed to analyze the information and data associated with the commercialization of space, interviews with aerospace executives, an

industry survey and a review of congressional records. Architecting complex systems can be achieved by using a collection of methods and approaches. They are the Normative (Pronouncement) Method, the Rational (Procedural) Method, the Argumentative Approach, and the Heuristic Development Approach. [16] Development of this proposed framework, for understanding value in the P/P Preparation Phase, requires systemic rigor and analysis to demonstrate appropriateness and completeness. The systemic rigor includes the context and judgments of a principle, along with a process, and supporting tools.

2.4.1. Architectural Approach

Architecting systems is a complex effort that requires different approaches for a given situation. Scholars tend to categorize them as listed above. This thesis uses the Heuristic Approach to define the appropriate context and judgments to be applied. Then system architecture and system engineering processes and tool frameworks are used to perform the analysis. Heuristics usually result from experience, insight, lessons learned and are commonly categorized as rules of thumb. They differ from scientific law in that they are qualitative in nature and are more difficult to replicate. The key being that the opposite of a heuristic will not make sense or will lead to failure.

The vantage points of using a heuristic can be shown in a few broad categories. Definitions (or scenarios) of these vantage points are shown below:

Theoretical: *Specified problem-structuring devices, ranging from decision rules to a variety of analogies, analogs, and models used to guide the search for solutions.*

General Pragmatists: *Widely accepted qualitative statements that, as judged from examples, add structure to ill-defined situations.*

Managers: *Commonly accepted insights, gained from experience that brings order out of apparent chaos.*

Engineers: *Statements of common, or contextual sense, that aid in concept development, problem solving, decision making, or judgments.* [16]

In this case, the Engineers vantage point is used to apply heuristics to the interface between the customer and the supplier of services during the P/P phase. The Engineers vantage is used because it provides a context for the application of data and tools and generates a condition conducive to problem solving. In the case of this thesis, the context is cancelled access-to-space systems. The problem exists in understanding the cause of the cancellations during the early stages of the lifecycles. To apply this heuristic, a principle and process must be selected. The remaining portion of this Chapter addresses these issues.

2.4.1.1. Principles

A variety of principles that address the activities of early product development were considered that take the perspective that ***Value occurs at the interface***. Rechtin defines the Principle selected for this thesis in his text, Systems Architecting, Creating, and Building Complex Systems. It states "Relationships among the elements are what give systems their added value." [16]

2.4.1.2. Process

The process employed is a systematic manner of applying the principle to a given situation in order to analyze it. In other words, the process is an organized approach to applying a set of tools in search of a solution that satisfies a certain set of goals. The process analysis also includes recognizing that the customer/supplier roles will evolve and change as the perspective on value changes. It is also important to note that a market analysis should be integral to understanding the commercialization decisions. The data to support this analysis process would include demonstrated needs derived from Congressional Records, interviews with aerospace industry executives in the Public and Private Sectors, survey information from experienced product development persons and a case study of failed space launch systems.

2.4.1.3. Tools

Tools are frameworks, approaches, analytical methods, and techniques that support the inferential extraction of information and its conversion to knowledge. The tools utilized for this thesis are categorized as Architectural, System Engineering, Strategic, and Mathematical. They are as follows:

(1) ***Technology Strategy and Managing Innovation*** - is a set of frameworks for understanding the implications of R&D Investments and product development approaches;

(2) ***Architectural Influence Mapping*** – is a framework for understanding the influences on architectural decisions;

(3) ***Quality Function Deployment (QFD) –*** is a methodology to relate goals parameters or attributes to a product or process implementation "How";

(4) ***Affinity Diagramming –*** a methodology for structuring random relevant pieces of information that facilitate hierarchical ranking and supports development of a QFD***;***

(5) ***Strategic Forces*** – Technology and competitive strategies are applied to segment the issues surrounding technology and market decisions; and

(6) ***Descriptive Statistics –*** Mathematical techniques to describe system behavior.

Now that the heuristic, context for analysis, and the tools are identified, the next step investigates where value resides in the PD process and determines its attributes. The Lean Aerospace Initiative (LAI) at the Massachusetts Institute of Technology (a consortium of Public and Private Sector organizations who are advancing the body of knowledge on Lean Principles and Thinking) have identified several models of value in the PD process. These will be discussed in Chapter 3.

Chapter 3 – Lean in Product Development

This chapter addresses the background information used to support development of the heuristic and its associated features. Lean Principles and Thinking are addressed along with information from the field of study associated with the Management of Services and frameworks for the strategic and competitive assessment of new products and market conditions.

3.2. Lean Application in the Product Development Process

Studies that apply Lean Principles and Thinking to the Product Development (PD) process points out the complicated nature of the relationships between customer, stakeholders, employee and the environment. Table 2 is a list of PD value models and their respective sets of attributes of value as described by a variety of researchers. [17]

Table 2 - Product Development Process Value Modes (adopted from [17])

PD Value Model	Attributes of Value
Information FFFT – McManus, 1999	• Form • Fit • Function • Timeliness
Enhanced DSM Modeling – Browning, 1998	• Cost • Schedule • Performance • Risk
PD Customer Value Model – Slack, 1999	• Functional and Performance Properties • Degree of Excellence (level of defects) • Development of Program Costs • Acquisition Costs • Operating, Support, and Retirement Costs • Product Lead Time • Product Development Time
Life-Cycle Value – Walton, 2000	• Mission Effectiveness and Performance • Scheduling • Sustainability • Affordability
General Attributes	• Knowledge • Effectiveness • Technical performance • Amount • Pertinence

	• Price • Life-cycle Cost • Delivery Timing • Reliability • Accessibility • Maintainability • Suitability • Functionality • Manufacturability • Operability

A key question from the work conducted by Chase, is "How can one model the creation of value in a specific PD processes?" Another question addresses the necessary tools. This thesis attempts to answer both questions through the proposed heuristic.

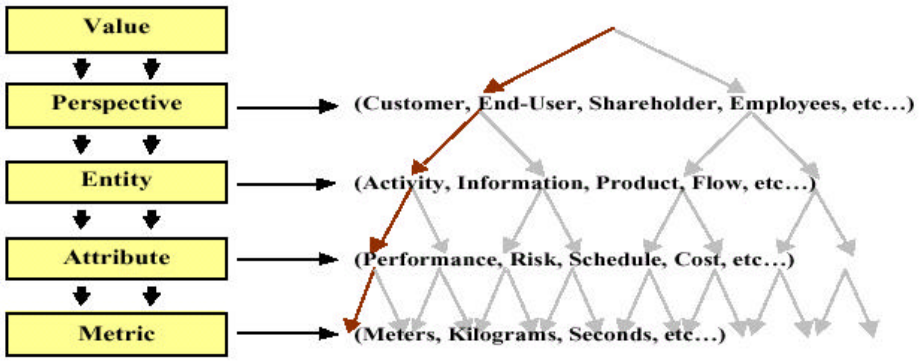

Figure 12 - Dimensions of Value (adopted from [17])

As Figure 12 indicates, value progresses from the perspective of the individual, ultimately manifested in the form of a metric or MOE that is meaningful for the given value creation process. Relative to this thesis, metrics would represent reduced conceptualization times, reduced document cycle times, fraction of population served/impacted, cost per-pound-to-orbit, and geographic dispersion to note a few. The model further implies that value is a function of the activity performed, the information generated, and the risk undertaken or mitigated. The result of this effort is value composed of activity quality and efficiency, information, risk and ease of information flow or communication.

The process that yields these MOE should be customer-based and focused on organizational activities to continually assure meeting the customer's expectations. It is management's responsibility to design

and implement internal operations that enable the satisfaction of customer expectations. They should be monitored relative to overall cycle time, quality, product, and cost. [18]

3.2.1. Value and Multiple Stakeholders

Customer value is the core of Lean Thinking and Management of Services. They both consider the perspective of the customer (Public and Private Sectors as well as the General Public) and use criteria and models to bound their application. The P/P Preparation Phase integrates value and the issues of multiple stakeholders with other goals and objectives, while maintaining value for all parties**.**

3.2.1.1. Value

"Value measures the worth of a product or service to a customer. It is a function of the product's usefulness to the customer, its relative importance to the customer's need, its availability relative to when it is needed, and how much the customer has to pay for it." [19] When considering the entire lifecycle, Stanke and LAI have similar definitions. The LAI definition is "A product introduced at the right time and for the right price which delivers best value in mission effectiveness, performance, affordability, and sustainability, and comparatively retains these advantages over the useful life of the product." [20] While considerably complete definitions, Stanke takes it a step further and specifies it in terms of "Balanced stakeholder expectations…and associated risks to deliver best value through the lifecycle…" [8]

3.2.1.2. Multiple Stakeholders

Complex system development will have multiple persons or organizations (stakeholders) with an interest in the successful completion of the PD process. However, stakeholder priorities will not be consistent, and thus, will result in tensions vying for compliance. It is during the P/P Preparation Phase that these tensions are sorted and prioritized relative to the objective(s) of the PD lifecycle. From a stakeholders' perspective, a Lean P/P ultimately results in satisfied customers and stakeholders along the entire Lifecycle and the accomplishment of strategic outcomes. [20]

3.2.2. Product Goal Setting

Goal and objective setting is critical to successfully completing the preparation stage of the lifecycle. Goals and objectives help solidify the expectations of the customer and the recognition of obligatory responsibilities on the part of the supplier. Goals and objective agreement is the basis from which technical and management measures are derived. The goodness of a goal is demonstrated via four characteristics: Completeness, Consistency, Representative and Humanly Solvable and Attainable. Completeness addresses the degree to which the goal captures and allows responses to the upstream and downstream influencing factors. Consistency addresses the degree to which the goal encompasses the strategies and compelling need for the effort. The degree to which the goal is representative of the situation is defined in terms of how well it captures the desired strategies, needs, competition, and governing regulations. Humanly solvable addresses how clear and concise, solution neutral and well aligned the goal is with the problem solving strategies. The goal also is reflective of the systems of systems concept and its upstream and downstream influences, which can be decomposed to address those that are enterprise-oriented and those that are related to implementation. [21]

Effective goals also include an association between metrics and desired value, resulting from obtaining the goal. The value portion is increased as the level of quantification is increased. This provides clarification of intent and assurance of understanding, which leads to successful implementation. Value can also be expressed in many forms such as continuous, discrete/logical, and qualitative. In parallel, metrics must be decomposable to the lowest level possible, and subsequently expressed as a single characteristic to focus upon.

3.2.3. Measures of Effectiveness

Measures of Effectiveness, used interchangeably with the term metrics, is the means by which Programs/Projects quality and value are measured. Commercially, Programs/Projects are measured in terms of benefit to the customer and benefit to the developing organization. These are manifested through measures such as return on investment, return on equity, reduced price, increased quality, network

externalities, and appropriability. When considering Public P/Ps, additional measures address national issues such as wealth distribution, security, people served, and quality of life improvement. The "ideal" MOE would be traceable to an over arching goal and be decomposable such that the product delivery process and design results are also decomposable into appropriate and meaningful MOE.

In the typical P/P management process, MOE's are heavily dependent on data, and in some cases, highly subjective in interpretation. An example would be the measure of Earned Value. Earned Value develops a historical picture of P/P performance relative to actual and budgeted schedule and cost. This measure is a standard and works quite well when sufficient resources have been consumed. However, in the case of the Preparation Phase, little or no resources have been expended and it is difficult to infer meaning from the application of such an MOE. When considering risk and technology readiness, MOE are again highly dependent on data and are highly subjective in terms of development and interpretation.

Now that the background information, which defines the heuristic, premise and features, applicable models and context for analysis, have been presented, they will be applied to a case study of the access-to-space market. Chapter 4 addresses key elements surrounding the market and competitive conditions. This case study will look at the strategies employed, technology development, and competitiveness to highlight opportunities for value capture and bring it to bear on the heuristic of this thesis.

Chapter 4 - Access-to-space Case Study

To understand the architecture of complex systems, like launch vehicles, it is necessary to understand the components and their influences on the process that extrudes the final product's form, fit, and function. These are shown in Figure 13. These components and influences are the foci of fields of study on their own and add complexities to the product development process that are manifested in terms of innovation processes, the social, political and technical issues and the technology and strategies sought and employed. The following sections provide a basis for understanding these concepts. [21]

Map Goals to Upstream Influences

Housing Development of Quality	Needs of Beneficiary	Regulations	Corporate Strategy	Competition/ Market Strategy
Functional	✔	✔		✔
Aesthetic/Spiritual	✔			✔
Quality	✔	✔		✔
Interfaces	✔	✔	✔	✔
Development Schedule	✔		✔	
Development Resources			✔	
Development Risk			✔	
Strategic			✔	✔
Financial Return			✔	

Figure 13 - Goal Mapping to Upstream Product Influences (adopted from [21])

4.1. Needs of Beneficiary & Regulations – Social/Political/Technical Issues

Acquisition Reform within the Federal Government has led to further complication of the customer/supplier relationship within the Public and Private Sectors. The cost of implementing complex systems using Government specifications has been costly and has succumb to pressure and given way to increased use of Commercial Procurement Practices (CPP). Also, the Government has taken the view that those participating in the acquisition process are customers as well, and that the cost of participation should be the lowest possible. Anderson in the thesis, A Study of the Federal Government's Experiences with Commercial Procurement Practices in Major Defense Acquisitions, highlighted these commercial

practices as options and compared their effectiveness in meeting the intention of the Acquisition Reform Act. [22] The basis of the study was twenty-three DoD programs and their use of the CPP options shown below.

- Commercial Specifications & Standards
- Performance Specifications
- Streamlined Contract Administration
- Government/Contractor Cooperation & Relationship
- Commercial-off-the-shelf/Non-Developmental Item
- Commercial Warranty
- Best Value
- Past Performance

4.2. Stakeholder Implications

The development of complex systems for the greater good of the public is the more complicated of the customer/supplier relationship combinations. This relationship is complicated by the fact that the end user is not an integral part of the process. As one of the interviewees stated, [it is] "…the battle of stakeholders that never gets sorted out and leads to a cloud of aspirants." [23] The result becomes an inefficient utilization of resources, a lack of focus and direction and questionable development of competitive advantage. "The reasoning behind this is that, in many cases, the value to the end user is not necessarily related to the cost of providing the product or service." [24]

In order to shed light upon this convoluted process and generate any hope of understanding the customer/supplier relationship, one must ask four questions.

- Who benefits from the effort?
- Who pays for the effort?
- Who provides the effort?
- Who loses because the effort is undertaken?

These questions are further complicated by the fact that solutions, derived under purely market driven or technical terms do not necessarily correlate with that derived under political conditions. It is the notion of fact versus perceptions that complicate the process. Rechtin and Maier developed a heuristic for architecting in this environment. It states that "It's not the facts, it's the perceptions that count" and is

followed by the statement that critical issues must be transparent to the political elite in order to convince the masses.

When considering who pays and who provides and determining who loses, the U.S. Congress becomes the ultimate customer in the sense they become the customer and stakeholder. The success of a P/P is directly related to its ability to maneuver and negotiate in order to secure funding. Funding has a direct effect on the P/P structure and organization as well as geographic dispersion. In addition to these effects, funding typically will have conditions attached that will determine the required communication between Congress and the P/P.

Traditionally, the Public Sector role (i.e., Government) has been to engage and pursue R&D activities in areas that are too risky for the Private Sector. For many years, these roles have been quite clear. Maintaining a close relationship with various segments of the Public Sector R&D was not necessarily the most profitable activities to undertake, but was considered a wise competitive strategy because of the opportunity to leverage technologies and improve the organization's knowledge base. In today's environment, it can be said that the roles have been reversed. The Public Sector is being downsized, spending significantly reduced and is now attempting to partner and share development costs, operations costs and risk with the Private Sector. This is in exchange for the opportunity to commercialize the end system. As a result, some believe that Private Sector R&D investment and effectiveness has surpassed the Public Sector in terms of breakthrough technologies generated. [25] Therefore, it could be said that the R&D investment strategy is governed by a commercial set of rules versus a public driven set of priorities.

4.2.1. Strategies (Public & Private) - Corporate strategy

The civil space program has set lofty goals of improving access-to-space. The Honorable, Mr. Daniel Goldin, former NASA Administrator, announced that NASA has set goals to reduce the cost of accessing space by an order of magnitude of 10, and safety and reliability by an order of 100. [26] These goals are the driving force to expand the bounds of technological advancement in support of improving

mankind's way of life; at the same time, affording opportunities for value capture by its participants. The result has been the structuring of technology development approaches that support the development of such lofty performance parameters and the identification of a strategy that satisfies both Public and Private Sector goals, including international competitiveness.

4.2.1.1. Technology

A descriptive indicator of the technological maturity is the use of "S"- Curve for a given technology. This framework plots a performance parameter against a measure of effort. The usefulness of "S"- Curves comes from providing indications of changes in technological progress and to hopefully provide an opportunity to recognize when switching to a new "S"- Curve is necessary. "S"- Curves can be viewed as having three phases: fermentation, take-off, and plateau, as shown in Figure 14. Each of these phases reflect relative technological gains for a given amount of expended effort to mature and focus a given technology. [27] "S"- Curves also reflect when a dominant design starts to take hold and drive the investment strategy associated with a given technology. Dominant designs are reflective of a communal agreement on a developmental direction and characteristics for a given technology or system. It starts to take hold following the "fermentation" stage and prior to the "take off" stage. "S"- Curves for Launch Systems and Vehicles can be developed according to the development of propulsion systems and payload capacity to orbit. [27]

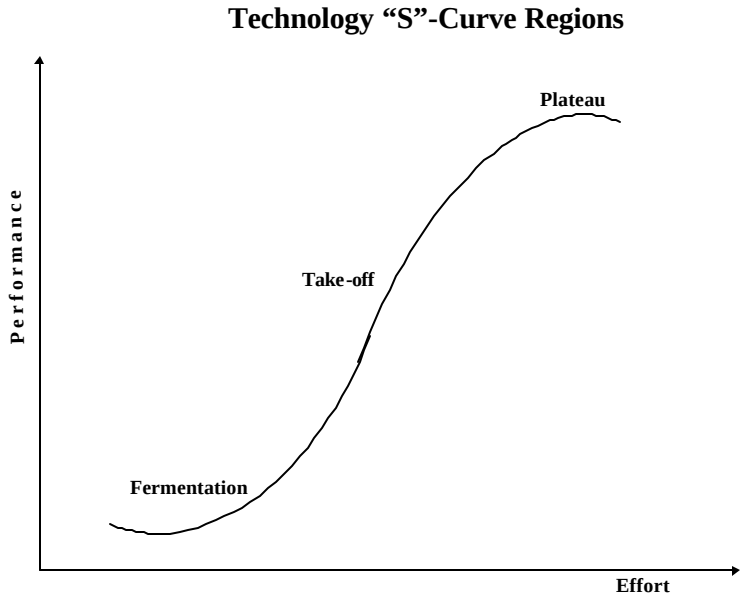

Figure 14 - Technology "S" Curve

Market conditions for satellite delivery to earth orbit has encouraged a reshaping of the current “S”- Curve. Competitors have modified this “S”- Curve by “reaching back” to existing technologies to exploit market conditions as shown in Figure 15. [27] They “reaching back” leverage knowledge, experience, and technologies, which included ballistic missile development, multiple stage system architectures, and hydrocarbon-based fuels to capitalize on new market opportunities. These technologies are now integrated with updated engineering and manufacturing techniques to foster greater competitive advantage. [28] The advantage comes from reductions in manufacturing costs, increased reliability in system components, and overall reductions in system weight.

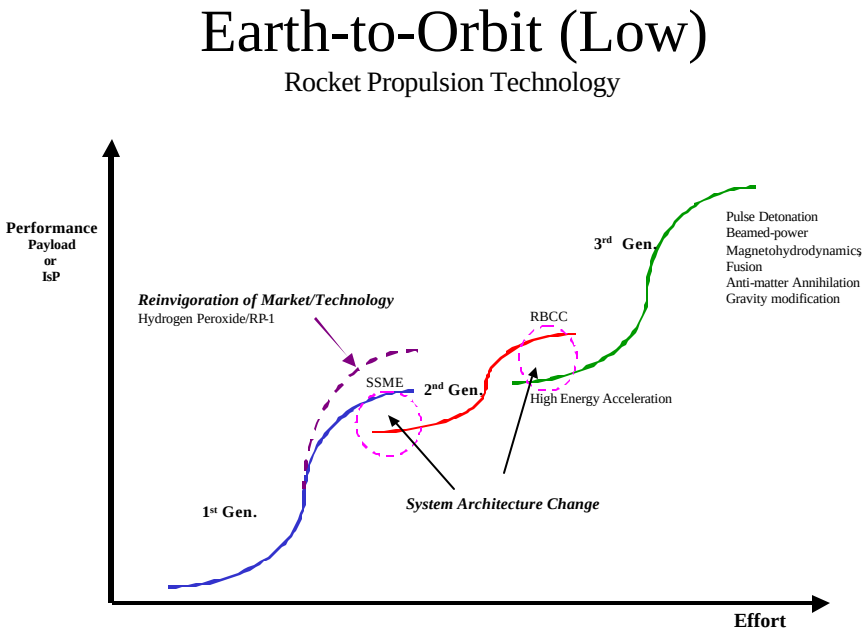

Figure 15 - "S" Curve for Rocket Propulsion Systems

4.2.1.2. Strategy Selection

Goodman and Lawless, in their book Technology and Strategy, Concepts Models and Diagnostics, suggests that strategies are not some random set of ideas, but are a cohesive set of thoughts to provide guidance to a decision making process. They also suggest that strategies should be the result of either a "fit" or "action potential" analysis. [29] This could result in the use of one or more of nine different strategies that are dependent on the specific product lifecycle and market conditions, and whether specific barriers to competitors are desired. The nine strategies are shown in Table 3.

Table 3 - Nine Technology Strategies (adopted from [29])

Strategy	Market/Product Situation	Actions/Defensibility
Technological Commodity Search	Stable or declining/well known or standard	Invest in productivity/low-cost firms exhibits uncertain imitability/market size-to-investment cost ratio favorable/potential for reputational differentiation
Preemption	Industrial/easily copied	Invest in mega-capacity plant/competitor investment too high given market size
Productive Efficiency	Mature mass market/stable and well-understood product	Investing in manufacturing process/competitor faces information delays regarding manufacturing technique-experience curve effect
Producer Preference	Early stage/complex product	Invest in product research/early steep learning curve provides information delay and early uncertain imitability
Production Flexibility-Seasonal/E'-Customer Design	Seasonal or low volume/custom design	Develop flexible manufacturing approaches planning and CAD/CAM/takes advantage of normal product information delays to the competition
Customer Preference	Mature-moderate to high volume/standard	Develop ability to manufacture with limited flexibility
Product Pioneer/G' Product Leader/G" Product Follower	Latent/new and technologically complex	Invest in product development/experience curve advantages competitor delays due to product complexity and market uncertainty
	Growing/technologically complex	Heavy investment in product and market development/better solution to large portion of market needs
	Mature/multipurpose products	Invest in special-purpose design/niche benefit of market size not worth competitor's investment
Vertical Integration: Forward/Backward	Large or growing/technologically complex	Enter into cooperative agreement/contractual regulatory
Complimentary Technology	Large market for complex product (computer/car)	Design product to be compatible

The market/product situation of the U.S. Launch Services capability reflects several of the strategies identified by Goodman and Lawless. The U.S. capability was declining in dominance, but can be considered stable, given recent growth in the communications market. The growth in the communications market has led to the re-use of well-understood technologies to provide access-to-space

services. However, over the years, many countries have also developed similar capabilities and have eroded some of the U.S. dominance. As a result, portions of the following strategies can represent the U.S. Launch Service sector: Technological Commodity Search, Preemption, and Productive Efficiency. [28]

The Technological Commodity Search strategy suggests investments in productivity to maintain competitive position and market share given the competition is on a purely price basis. The U.S. is investing in launch systems like the EELV that leverage existing architectures, and applying state-of-the-art design and manufacturing to further reduce costs. Aspects of Preemption strategy address the fact that launch services can be imitated. This comes because of national policy influences on international diplomacy, and not necessarily affording the greatest protection of the capability. The suggested action from this strategy would be to invest in additional capacity to point where competing nations cannot afford the cost of additional capacity to compete on low prices. Lastly, the Productive Efficiency strategy suggests investing in manufacturing processes to provide distance and differentiation between service providers.

The steps taken by the U.S. in recent years have led to segmenting the U.S. access-to-space capability such that immediate launch services are covered by the DoD and ELV's, and the future to be addressed by NASA and reusable type vehicles. The ELV effort is focused on improving competitiveness through investments in productivity and manufacturing, which is consistent with the Technology Commodity Search and Preemption strategies. [29] Furthermore, plans to open more spaceports align well with the strategy for capacity increases, which make it difficult for competitors to imitate. This defensive posture is reflected in the EELV commercialization effort, where Lean Thinking and Principles have been employed to manage systemic cost. However, the commoditization of launch services is a sub-optimization of the value chain when considering the perspective of satellite developers and ground base users. Launch services make up such a small portion of the revenue stream (9%), that efforts to emphasize cost reductions are inconsequential in the grander scheme. [28]

The RLV strategy seems to align with that of Product Pioneer and Vertical Integration strategies. These strategies highlights the fact that new technologies are required to make RLV a feasible means of accessing space. The market conditions must be properly defined to develop sufficient return on investment. Current thoughts suggest that space tourism; on-orbit recovery and maintenance of satellites are mechanisms to generate sufficient flight rates. [30] These concepts are not necessarily in agreement with the thoughts of some industry executives who feel the space tourism model is not well defined and the current cost of satellite development does not support on orbit maintenance of satellites. This situation is further complicated by the failure of the X-33 CPP effort.

4.3. Competitive Issues

In defining and establishing Public Sector programs, strategic implications must be addressed in a broader sense than purely for the Public good. Competitiveness objectives require the incorporation of a strategy that the Private Sector finds reasonable and can be leveraged for economic gain. Efforts to date are implementing strategies to commoditize launch service prices. Figure 16 shows the migration toward commoditization of launch services costs. This strategy requires competition on price. However, market volatility is flexing the size of the market. Therefore, launch capacity and flexibility are becoming more important. [28] With investments in associated R&D shrinking, it is difficult to maintain a competitive edge on price. This is because information surrounding system development and increasing reliability have been shared with global competitors via a variety of alliances. These alliances tended to focus on improving quality of life and became a part of international diplomatic policy. Therefore, any appropriability derived from competitive barriers and strategies have been eroded. The necessary complimentary assets, in terms of infrastructure and vehicles, were subsequently developed internally with competitive quality. [31] This act alone reduced the competitive advantage of the U.S. and brought to bear a new threat on the national security front. It also improved the knowledge base of its Alliance Partners with respect to developing a credible launch system capability.

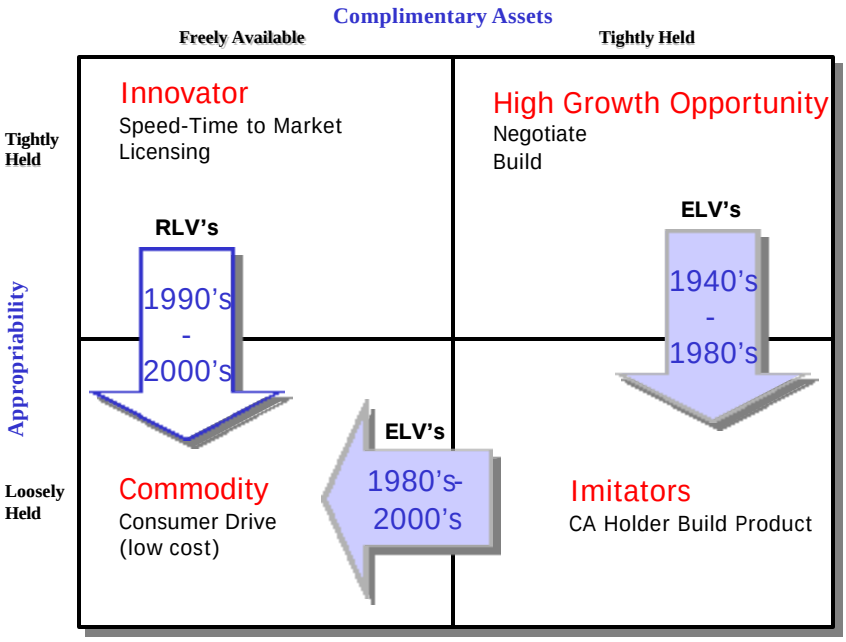

Figure 16 - Government Policy Effect on Access-to-space Value Capture [31]

Commoditization of the launch service market is a classic situation where the innovation process, for a given technology, has matured in terms of value extraction opportunity. According to Utterback, any remaining value can be extracted through process improvement versus additional emphasis on the product itself. [32] Figure 17 reflects the relationship between product and process innovation where opportunities exist to innovate and extract value. Launch services and systems are obviously in the latter phase, where hardware innovation is extremely limited and process improvement offers the greater opportunity. This is demonstrated in the fact that current systems architectures, used worldwide, are multi-stage systems, and still use the ground infrastructure of the early 1950's vintage. Furthermore, current development efforts have focused on improvements in the design/development and manufacturing technologies employed, in order to reduce vehicle and launch operations costs.

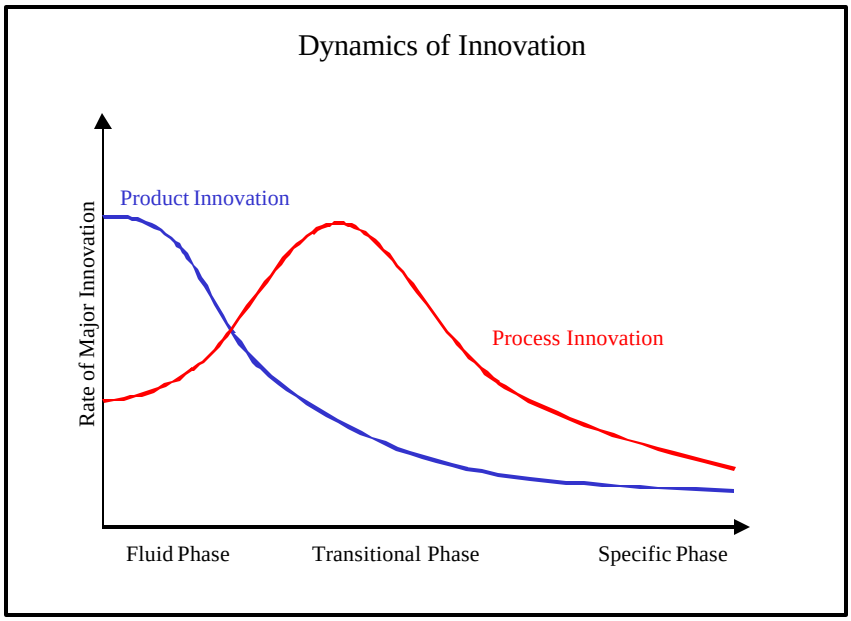

Figure 17 - Product/Process Innovation Dynamics (adopted from [32])

4.4. Organization

Still critical to success is the manner in which P/Ps are managed. This is reflected in the leadership style, the structure of the team, and relationships with its customer(s) and supplier(s). Dependent upon the greater organizational culture, P/P Managers will take on characteristics indicative of either "Heavyweight" or "Lightweight" management style. Heavyweight management is given great range and authority to direct and manage internal resources (e.g., people and funds), to influence the customer/supplier relationship, and to effectively resolve issues. Lightweight management has far less authority and is overshadowed by the power of functional organizations relative to internal resources and other management issues, when considering customer/supplier relationships. As a result, Lightweight management is somewhat ineffective in managing its circumstances relative to changing environmental conditions and influences.

In order to become closer to the customer and reduce the development cycle time, Integrated Product Teams (IPT) have been utilized by numerous Public and Private Sector organizations. IPT is an organizational tool to bring the right functional or core competence skill(s) to the development process.

Successful organizations recognize that core competences are critical to the future and put forth great efforts to maintain them. IPTs become a mechanism for a given product development activity to efficiently and effectively leverage tacit knowledge surrounding the processes, methods and modes of operations. This is especially true when resources are limited and decentralized, which can be the case when employing IPTs. [33, 34] In other words, it is an opportunity for systemic innovation, which has a broader view, to occur within the team versus the autonomous approach, which is more element-focused.

Survey information, shown in Appendix B and summarized in Figure 18, reflected the propensity of organizations to have their P/P Managers style be somewhere between Heavyweight and Lightweight. The obvious desire is to have a hybrid of these two states as the norm; Lightweight is identified as the next most prevalent management state. The survey data also reflects the impact of better goal and objective setting, along with commitment to the efforts undertaken, which lead to better relationships and reduce perceived risks.

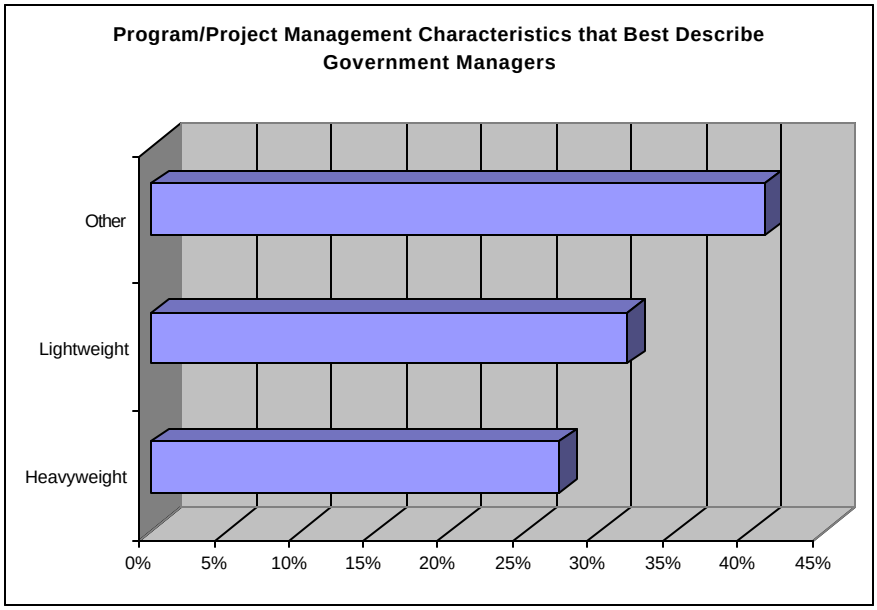

Figure 18 - P/P Management Characteristics of Government Managers

Relationship management and management tendencies are important when considering the accomplishment of organizational goals and customer satisfaction. Organizations must maintain the

alignment of its goals and behavior with those of the customer. Some organizations have implemented a balanced score card to measure performance, to provide guidance to management and to support decision-making. A typical balanced scorecard is shown in Figure 19. [18]

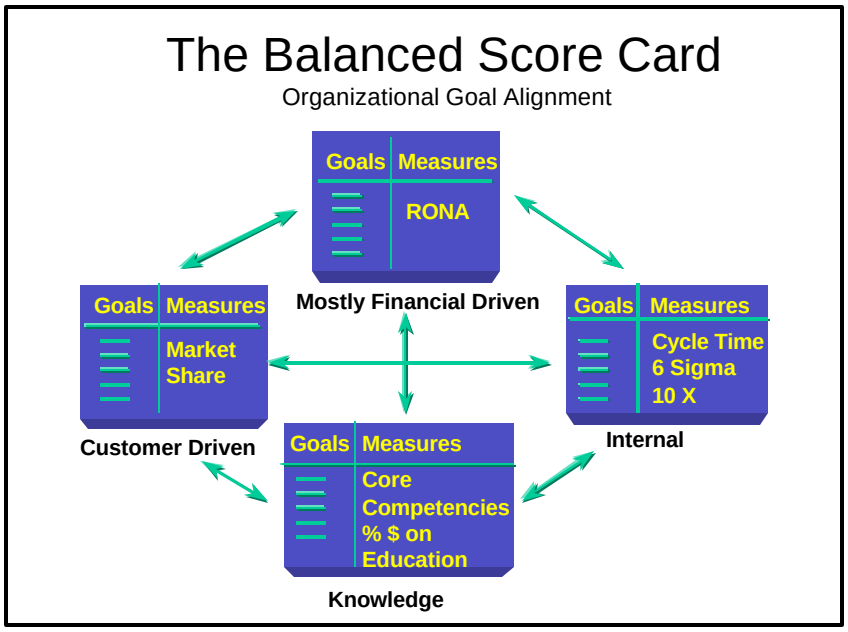

Figure 19 - Typical Balanced Score Card (adopted from [34])

Over the past few years, the aerospace industry has seen the number of competitors be significantly reduced to approximately two major organizations with enough capacity to take on complex system development activities. [35] From a P/P Management perspective, this situation can and does conjure up notions of whether the best value will result from such a condition. Coupling this condition with the lack of a compelling need to drive technological development, the situation is ripe for inefficiencies to flourish.

Previous development activities, which included multiple vendors and possessed an obvious compelling national need (e.g., putting man on the moon or national defense), saw timely development of critical technologies that now form the infrastructure and prevailing vehicle architecture for which U.S. competitive advantage is based. It is recognized that the national and international conditions have changed significantly and that the willingness to apply the same level of resources also does not exist.

The current conditions point directly to the possibility that the system cannot effectively meet such lofty goals and objectives as described by Mr. Goldin. [36, 23]

This customer/supplier condition is a potential breeding ground for lack of trust to grow. This condition is said to have the propensity for "hold-up" to occur on the part of either participating party. In this environment, the risk versus reward situation is questioned as to its sufficiency in enabling trust for both parties to grow in a positive manner. [37]

Survey information reflects a perception that, in spite of the history of program cancellations and the development of systems that do not satisfy expectations, the relationship between the Government and its support contractors is still good. However, when combining the descriptors of Fair and Poor, they equate to fifty-five (55%) of the respondents, and reflect significant deterioration of the relationship as shown in Figure 20.

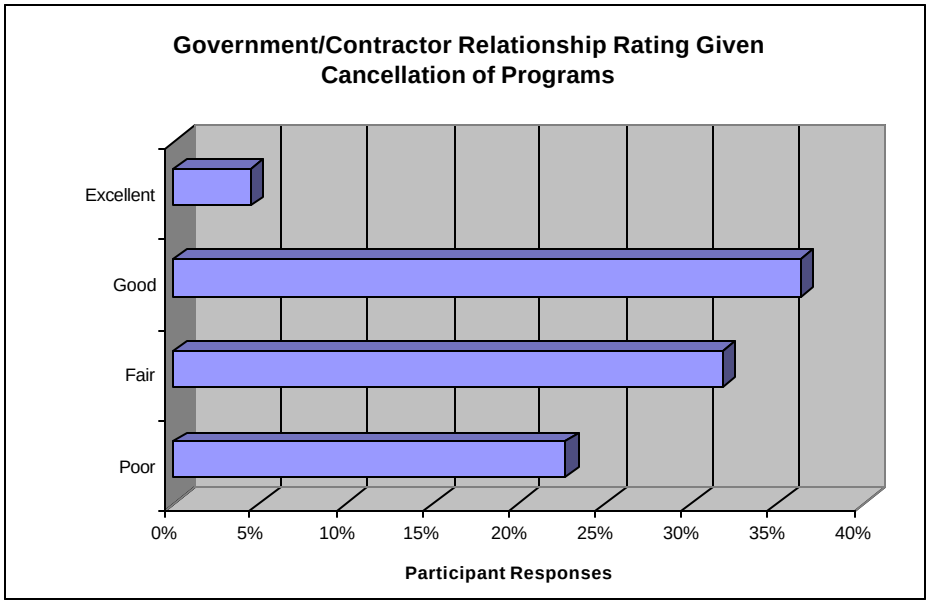

Figure 20 - Government/Contractor Relationship Rating

The Government has incorporated CPP to increase the value of the process undertaken during the procurement process, that makes it attractive to the private sector. This attractiveness used to be access to

technologies, otherwise not available. Today, it means a process for sharing cost and risk in developing complex systems. The cancellation of programs like X-33 and X-34 sets in place a mind set that the Government has no misgivings associated with reneging on its portion of the cooperative/relationship procurement strategies. In other words, the value to the Government is sufficiently high that reneging (cheating) is more valuable than not, when considering the downstream opportunity to leverage this cooperative/relationship procurement strategy in the future. (See Figure 21)

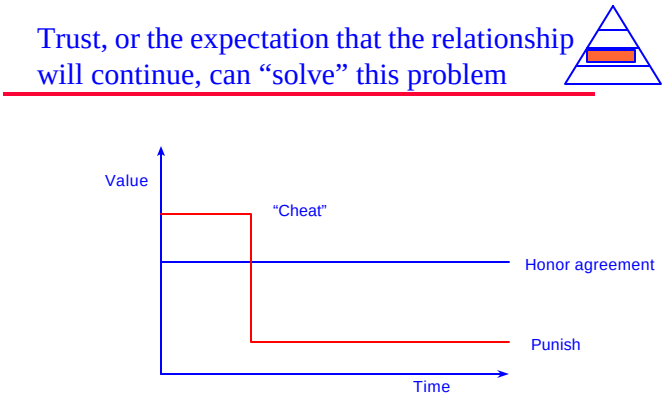

Figure 21 - Repeated Games Framework (adopted from [37])

4.5. Architectural Innovation Issues

Architectural innovation, as presented by Henderson and Clark, attempts to relate the manner in which components of a product come together but leaves the core concepts in place. This concept cannibalizes the organization's knowledge concerning a particular product or system, but preserves its knowledge concerning the components that made up the previous system. Innovation, in this article, is categorized as radical and incremental, relative to the degree to which the relationship is changed. Incremental innovation allows an organization to do new and different things while still using existing technical and commercial skills. Radical innovation requires a very new and different set of skills that generally lead to new markets and new competitors in the market. Figure 22 is a 2-by-2 matrix that provides a framework for analyzing situations where innovation issues are paramount. [38]

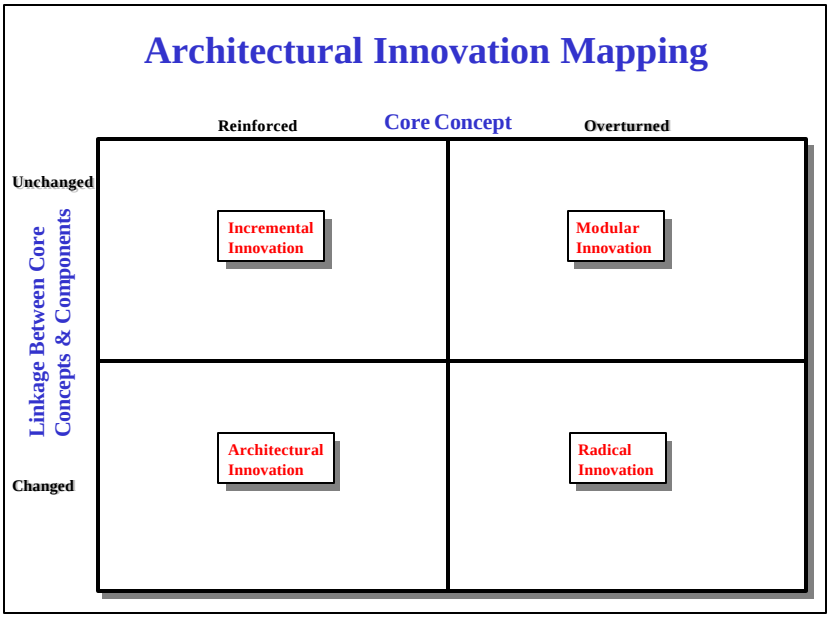

Figure 22 - Architectural Innovation Mapping [38]

Architecturally, launch systems and associated infrastructure have not changed significantly since WWII. During the first 20 years following the war, significant efforts were made in launch system development. The number of derivative vehicles, from a base of R&D expenditure, was quite large. An example would be the Saturn or Titan launch systems, which easily, has four to five derivative vehicles, from the core architecture with increasing capability. However, systems like Shuttle-C and EELV are actually small departures from existing architectures such as the NSTS and ballistic missile systems. In cases of NASP, portions of 2nd and 3rd Generation Space Launch Initiative, activities require radical changes in architectural concepts to achieve performance targets of $1000/pound to low earth orbit. Recent cancellations occurred due to not being firmly rooted in either the incremental or radical change camps. An example would be X-33, which employed very little radical technology and having its optimum performance window being a small portion of its mission profile. [39] The only functioning programs in Figure 22 are (1) EELV, which is firmly within the bounds of incremental changes, (2) X-37/40, which include modular technology incorporations, but at an extremely small scale and (3) the Shuttle, which at its inception, was an architectural innovation change.

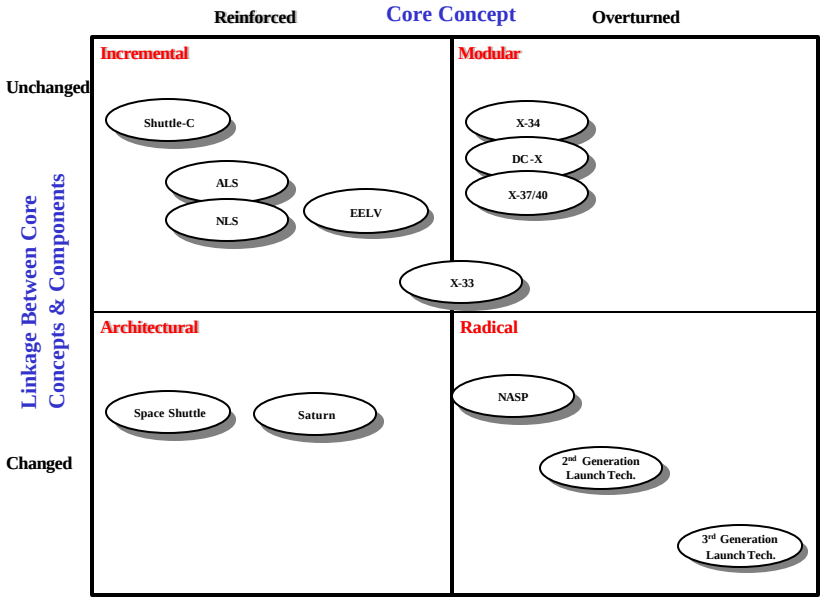

Figure 23 - Architectural Innovation Mapping

Currently, the role and responsibility for exploitation and development of access-to-space technology has been split between NASA and DoD. NASA is responsible for long term, complex, risky, and exploratory activities. The DoD has responsibility for near term, dual use systems that support both defense needs and near term commercial capability. Taking these roles and overlaying their current programs for achieving their respective missions, Figure 24 was developed. [28] NASA is using the Space Launch Initiative, that encompasses three efforts, (1) focused on improved safety in operating the existing NSTS system, (2) 2nd Generation, which leverages technologies with readiness levels to achieve RLV type access-to-space and (3) 3rd Generation which is conducting basic research in areas of propulsion such as anti-matter. [28] The DoD is focusing on maintaining the existing fleet of ELV's with a focus on national defense and global competitiveness. However, improved capability is needed due to increased satellite capability and weight. [28] In the long term, R&D investments must act on closing the "gap" between platform architectural impacts and that of breakthrough impacts.

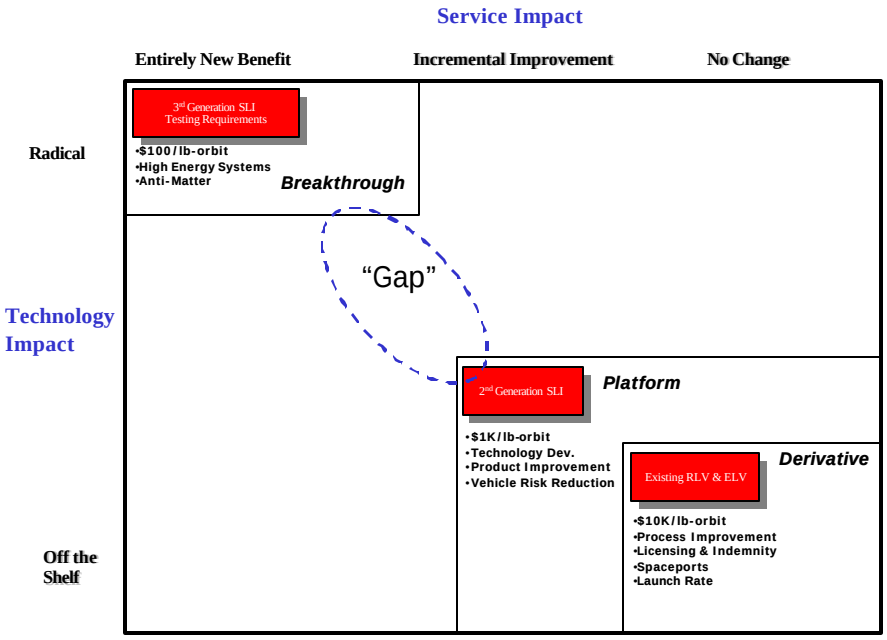

Figure 24 - Access-to-space Technology Development Mapping

In the next chapter, the results of this case study will be brought together with other data derived from interviews with industry executives, additional survey information, and a review of congressional records. This information will be analyzed and inferences derived to support a proposed framework based on the heuristic of this thesis.

Chapter 5 – Analyses

The analysis approach for this work utilizes Affinity Diagramming, Quality Function Deployment (QFD), Surveys, Interviews, and Model/Trait mapping as shown in Figure 25. The Affinity Diagramming is used to categorize the thoughts and views extracted from the data sources. The associated priorities are derived from the survey data, interviews, and congressional review. This is achieved through frequency calculations, which are detailed in Appendix A. The information serves as a basis to populate the QFD. The QFD is used to integrate the data into information where inferences can be made about the customer/supplier relationship. Model/Trait mapping is used to relate the results of the Affinity Diagramming and that of the survey to the Servqual model framework. All of this is used to address the heuristic, premise and features, and identify opportunities for follow-on efforts.

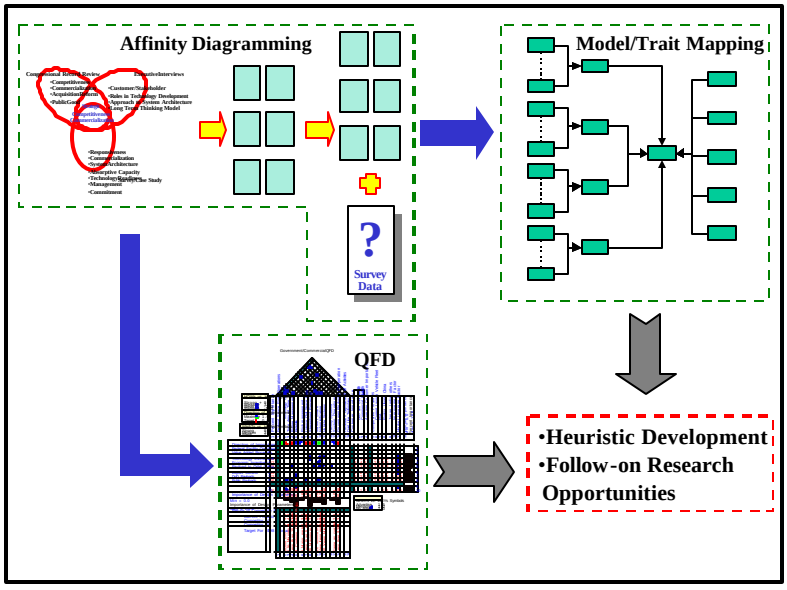

Figure 25 - Analysis Approach

5.1. Executive Interviews

Executive interviews were conducted to provide a more current and diverse perspective on the development of complex systems and the issues that influence their success. Six executives were interviewed: two (2) from the Private Sector and four (4) from the Public Sector. Their experience base,

on average, exceeds twenty years and covers aircraft, space transportation, satellite systems, space ground support systems, and military ship development and operations.

The common threads from the interviews were strategies, goals and objectives, understanding roles and responsibilities, and compelling need. Strategy encompassed a variety of ideals: acquisition approach, the desire to commercialize, and technology development. Private Sector participants expressed great concern for the relationship/cooperation acquisition strategy employed by the Government as being too risky when balanced against stockholder values. Public Sector participants voiced a similar concern when relationship/cooperation takes the form of IPTs and combines Public Sector and Contractor personnel in common workspaces. In both cases, the acquisition strategy did not result in the gains, savings or risk reductions desired by either parties.

Goals and objectives are of equal concern from both sectors in terms of clarity: what the U.S.'s policy is relative to space? Programs are initiated without solid connectivity to overarching requirements, and are not properly resourced. In addition, it is agreed that the U.S. involvement in space should be for greater reasons other than commercialization of low earth orbit (a greater compelling need). As it happens, the establishment of a compelling need, that is palatable to the general public, as well as its representative (Congress), is constantly overshadowed by the means of transportation. This is a fundamental violation of architecting a system in that a solution is identified too early. It was also pointed out that large efforts tend to loose sight of their goals too quickly.

Relative to technology development, the need for Private Sector participation in Government sponsored R&D is small, because in many cases, the return on investment or technological gain is not large enough. Given the notion that the U.S. industrial base is migrating towards fewer and fewer prime contractor organizations, the entire budgets of some Federal Agencies are not attractive enough to outweigh the risk associated with a developmental relationship. [35] This is especially true when considering the recent DoD Joint Strike Fighter $200 Billion dollar, multi-year award. Other areas are not completely ignored, but the question exists of who is going to pay for the necessary R&D that supports incremental innovations? Opinions are polarized where one party pays while the other leverages.

In general, commercialization was not very high on the list of importance and current efforts were not looked upon as having an opportunity to be successful. An example would be the NSTS effort, where the United Space Alliance organization is used in an attempt at commercialization. This is reflected also in the notion that the economics don't support the recovery or on-orbit maintenance of vehicles or systems. Until the technologies are developed, which will require significantly greater R&D investment, RLV's are not an economical choice for access-to-space. Also, it is believed that it is cheaper to build new satellites rather than attempt to repair on-orbit, which conflicts with proposed modifications to the Space Launch Act. However, R&D investments, from some of the cancelled programs resulted in improvements in performance and safety of existing systems. This is especially true in the area of propulsion systems. The elements from these interviews are detailed in Appendix A and drawn from References [2], [23], [43], [44], [45].

5.2. Congressional Records Review

The Congressional records review consisted of database searches for committee hearings associated with access-to-space, commercialization of space and reusable launch vehicles. In addition, other sources that monitored congressional reports, such as, Space Future®, NASA Watch® and Aviation Daily®, were reviewed. Congressional records pointed out the issues sited by Rechtin and Mair in that it is difficult to execute complex system development activities over long periods of time in a political environment. The opportunity exists for stakeholder priorities and values to change, and setup events that could lead to difficult or unsuccessful development efforts. It is not the fact that value or priorities have changed; it is the perception that nothing has changed that is real. Therefore, inconsistent and unrealized goals, objectives, and MOE must be explained.

The most significant result from this review is the role of Government in complex system development efforts sponsored by the Government. The X-33 program was set up as a relationship/cooperation, where both parties shared cost and risk. It was also believed that the Private Sector could provide the best value with minimal Government interaction. Now that the program has

been cancelled, the Inspector General testimony points to NASA for not providing enough oversight to adequately manage the effort. This is contrary to initial intentions. The review also indicated questions as to whether Congress itself should be a greater participating role in future complex system development efforts. The customer/supplier relationship becomes more like stakeholder/developing Agency/Contractor, where the stakeholder has a greater participative role than in the past.

The Congressional records review identified the desire to shore up the competitive edge of the U.S. launch services market while maintaining the public safety. This competitiveness was also fueled by the desire to shift the ownership of some U.S. Government installations to Local Government and Private Sector ownership to convert them to Spaceports. In many cases, this could be obtained by leveraging the existing infrastructure of down-moded U.S. Government facilities. Relative to public safety, the Government would provide indemnification for these Private Sector organizations for amounts above what commercially available insurance would cover. In addition, the Government would provide means for assuring safety through a licensing process with minimal impact to launch window opportunities. However, this licensing only addresses launching payloads to orbit. Some testimony indicated a desire for the Space Launch Act to be modified to include the recovery of vehicles from space. The belief is that the modification would open the market and improves the value of RLV's.

Current efforts, reflective of market pull, have resulted in partnerships between U.S. organizations and those of other nations, in order to satisfy the demand for launch services. These partnerships exist because of increased cost (in terms of risk) associated with launching within U.S. boundaries. To launch from a U.S. spaceport requires a license and interaction with as many as four different Federal Agencies. The Federal Aviation Administration, who is responsible for issuing the license, has agreed to keep the approval cycle time to less than 180 days. Other Federal Agencies are required depending on the launch site of choice. The elements from this review are detailed in Appendix A.

5.3. Access-to-space Case Study

The Access-to-space case study highlighted the notion that launch services are responsive to market conditions. This was reflected in the U.S. Department of Commerce projections of satellites to be launched into Low Earth Orbit (LEO) from 1995 through 2000. These projections showed a peak of almost 60 launches occurring in 2002. However, with the demise of the Iridium business model, market projections were sizably reduced where the 1999 projection was slightly over 20 launches occurring in 2010. [28]

Another major point derived from the study is the notion of commercialization. The U.S. has for many years leveraged its investments in post WWII ballistic system to nurture and lead a commercial space launch market. However, policies employed during the development of the NSTS consolidated investments in R&D and infrastructure into a single program, the NSTS. During the years to follow, the U.S. expendable launch vehicle dominance was significantly eroded to where it was on par with the rest of the worldwide launch competitors. Only after the Challenger explosion, was this policy reversed and dominance regained. [28]

To compensate and respond to the market pull, mature technologies are being integrated with state-of-the-art design and manufacturing technologies, to make for a better competitive position when considering the dollar per pound to orbit MOE. In order to reach the desired MOE of $100/lb, or even $1000/lb to LEO, significant R&D investments are required to encourage "Breakthrough" type gains in enabling technology.

In order to reduce access-to-space costs, reusability through reductions in the number of disposable parts are paramount. This also includes improved vehicle and payload process management associated with ground and support systems. For the most part, the system architecture employed has not changed since the end of WWII. Propulsion systems are chemical-based, dominated by hydrocarbon-based refined kerosene, oxidizers, monopropellants such as hydrazine and other volatile chemicals (e.g., hydrogen, hydrogen peroxide, and fluorine). Later emphasis was placed on efficiency and maximizing specific impulse (Isp) to achieve payload to orbit goals. This emphasis resulted in a highly efficient, yet

technically complicated and costly to operate class of engines, like the Space Shuttle Main Engine (SSME).

Architecturally, ELV and current partial RLV systems utilize multiple expendable stages, reflective of the early launch system efforts. The associated design and development processes still result in complex vehicles, ground systems, and payload integration efforts. Each one of the launch vehicles is unique in that accepted deviations from the prescribed specifications are peculiar to that system only. These deviations are the result of variations in the manufacturing and acquisition processes.

Ground systems are not much different in their maturation when compared to ELV's and RLV's. These operations are still labor intensive, complex, of questionable reliability, and consequently, take notable amounts of time and funding to perform. These conditions are the result of using volatile chemical propellants and critical processes that are inherently dangerous operations. Because of the high dollar value of equipment and safety of personnel, great care is given to processing such that the highest opportunity for on-orbit success is afforded. [28]

Failure of the access-to-space systems shown in Figure 1 can be attributed to the "gap" between the expectation of the system developer, the Public Sector, and Public/Private Sector partnerships, and the perception of actual characteristics of the associated management and physical system performances. Table 4 summarizes the issues surrounding each of the vehicles, probable causes, and lessons learned.

Table 4 - Summary of Rationale for Launch System Cancellation or Performance Failure [4]

Product	Status	Failure or Performance Problem	Cause(s)	Lessons Learned
NSTS	Operational	• Launch rate: Promised 60/yr, Actual 6/yr • Payload-cost-to-orbit: Promised $100/lb, Actual- $10,000/lb • Vehicle Dominated Architecture	• High Fixed Costs • Complex Payload Integration • High Touch Labor Content • Disposal Rocket Architecture of the 50's & 60's	• Avoid Flight-to-Flight Certifications • Decision Making only at highest levels • Avoid Dependence on Complex systems and operations • Reusable system necessary to reduce costs
HLLV Shuttle-C	Cancelled	• Payload-cost-to-orbit: $1000/lb • Increased number of disposable elements	• Reuse of NSTS Architecture & Infrastructure • Qualification of flight Software • Cost of disposable components (SSME)	• Flight qualification of software is costly and critical • Use of SSME is too costly for disposable architecture
ALS	Cancelled	• Payload-cost-to-orbit: $1000/lb • System Development cost to high • Satisfy DoD and Civilian Requirements	• Launch rate not expected to payback on investment • Propulsion system technology development • Cost of reliability for disposable propulsion	• Incorporate propulsion system technologies in SSME
NLS	Cancelled	• Payload-cost-to-orbit: $1000/lb • System Development cost to high • Satisfy DoD and Civilian Requirements	• Launch rate does not support payback on investment • Propulsion system technology development • Cost of reliability for disposable propulsion	• Incorporate propulsion system technologies in SSME
NASP	Cancelled	• Owner of Mission • Operational Costs • Satisfy DoD and Civilian Requirements	• High Technology Development Costs • No Commitment to Full Scale	• Technology investment critical

			Development	
DC-X	Cancelled	• Political/Culture Support • Vehicle Destroyed in flight test	• Significant architecture Differences • Failed actuator to lower landing gear	• Demonstrated Flight rate and operational goals (reliability, safety) are achievable
X-33	Cancelled	• Failed composite fuel tanks in structural tests • Weld joint failure during AlLi weld procedure development	• Permeability of composite materials can not contain LH2 • Unqualified weld	• Deeper Understanding of Technology maturity
X-34	Cancelled	• Benefit analysis no longer favorable • Development costs of propulsion system increasing	• Project Management • Cost of risk management unacceptable	• Program Review • Improved decision making process

5.4. Survey

The survey shown in Appendix B incorporates questions surrounding the P/P Preparation Phase and its characteristics, other P/P management issues, acquisition risks, and relationships between Government and Contractors given the plenteous occurrences of program cancellations or lack of satisfactory performing systems. The survey also addresses the correlation[6] between the Management of Services characteristics and the Value Creation Framework as presented by Stanke.

The survey was sent to 40 individuals, experienced in the development of complex systems, within the Public and Private Sectors, as well as varying experiences with Government contracting. The 40 participants were contacted via e-mail and solicited to participate in the survey because of their individual and collectively vast and broad experiences in the realm of P/P management. Of the total persons contacted, only one e-mail was returned as undeliverable, thereby resulting in a total population of 39. Of the 39, fifty-six percent (56%) of the participants responded. Fifty-five percent (55%) of the participants have between five and ten years of experience and is closely followed by those having 10-20

[6] Correlation, within the context of this thesis is not statistically based, but is based on survey participant responses to a given set of terms using common definitions.

years, which constitute thirty-two percent (32%) of the population. Forty-five percent (45%) have work experience in the Public Sector, which was associated with either Federal or State levels of Government. Twenty-three (23 %) of the respondents have experience in the Private Sector. To quantify any overlap in work experience covering both the Private and Public Sectors, the participant selected "Both." Thirty-two percent (32 %) of those surveyed indicated both areas of experience.

Participants were asked to correlate product development issues in terms of relative importance. The results are shown in Figure 26. Clearly, Timing and the Ability-to-Adapt to Changes in the environment surrounding the development activity were of greatest importance. Procurement Practices, Roles, and Responsibility closely followed. Market Dynamics was recognized as being important, but at a slightly lesser level of importance.

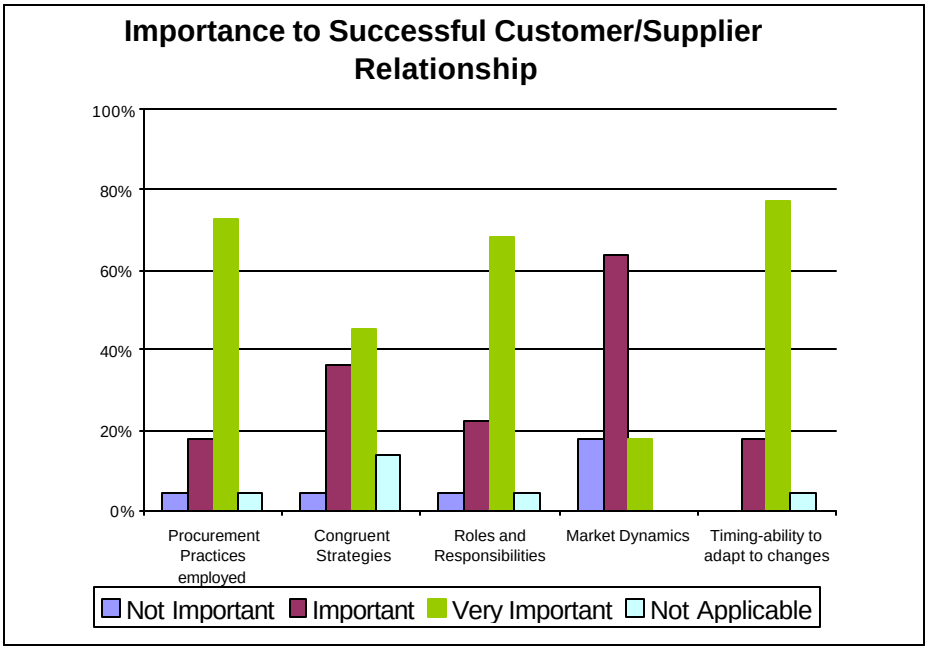

Figure 26 - Product Development Issues, Ordered Relative to Importance

When considering experience with CPP, a symmetrical implication exist: forty-five (45%) of the participants indicated that their greatest experience is with past performance; and 45% also indicated an infrequent experience base with Government/Contractor Cooperative and Relationships. In addition, cooperative/sharing type relationships are somewhat of a new approach to developing complex systems

and reflect a lack of experience on the part of both the Public and Private Sectors relative to this strategy implementation.

To provide some insight as to the strategic implications of CPP on the success or failure of a development activity, participants were asked to correlate CPP to the success or failure of a program for a given set of development environment conditions. Cost issues dominated the perception of the respondents because of its frequency of occurrence as the ranking influence. When dealing with technical challenges, organizations with a performance history of solving difficult challenges are desired. Cooperative/ Relationships are perceived to be more aligned with addressing issues in the political environment. This is reflected in Figure 27.

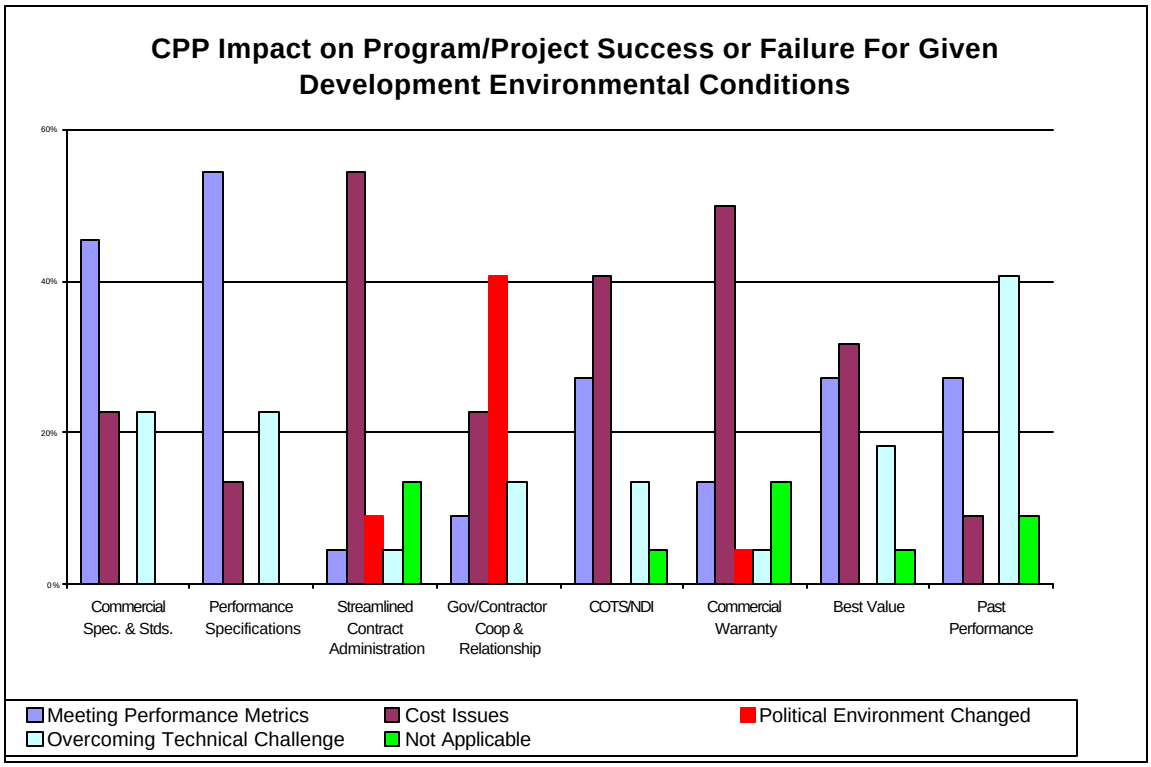

Figure 27 - CPP Correlation of Development Environment and P/P Success or Failure

The top five risks associated with CPP application surround item performance, stability of requirements, inconsistent goals and objectives, commitment in terms of funding, and a lack of standard commercial practices to employ. For comparison purposes, the top five items from Reference [22] were (1) item performance (by a large margin), (2) fair and reasonable price, (3) lack of standard commercial

practices, (4) interoperability and (5) trust in contractor.[7] This comparison is shown in Figure 28. This change could be the result of different participant organizational positions and the lack of focus on a particular P/P. In addition, interoperability is a strong driver amongst military system development and is the reason it ranks high in Reference [22]. This could also be reflective of development activities in the aerospace community where traditionally close coupling of missions, functions and systems was not perceived as a good attribute. This is because of the uniqueness in missions and the potential down side of political dynamics. [24]

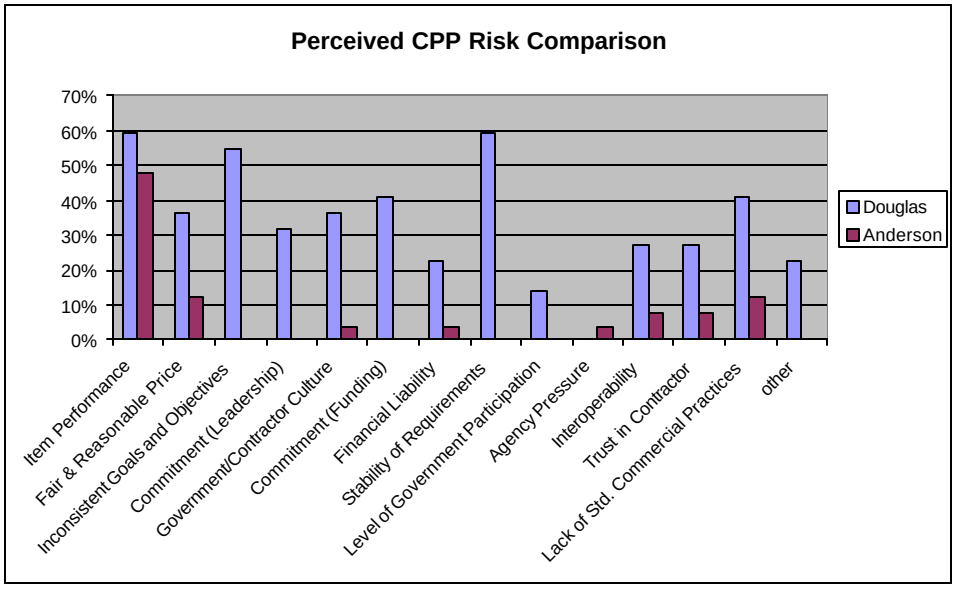

Figure 28 - Perceived CPP Risk Comparison-Douglas & Anderson

Survey participants indicated that they often used performance specification as the main element of complex system acquisition strategies. This was followed by greater than forty percent (40 %) indicating frequent use of past performance as the main element. An infrequent use of Government/Contractor Cooperative Relationships for CPP is shown in Figure 29. Participants indicated virtually little or no use of Commercial Warranty in their experience base.

[7] Reference [22] (Anderson) surveyed 23 projects and each project was given one choice. In addition, the population of Anderson's work was DoD programs versus the broad based population used in this thesis. The choices for this thesis' survey were augmented with commitment (Leadership and Funding).

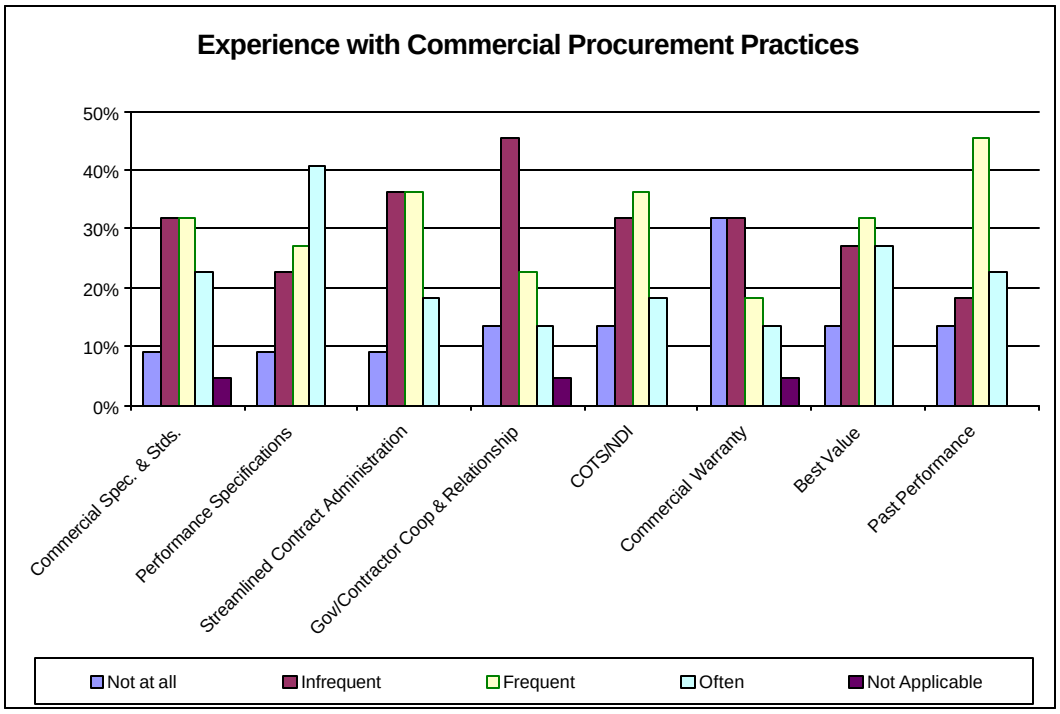

Figure 29 - Experience with Commercial Procurement Practices

Survey participants were asked to correlate service quality traits to BLV attributes based on common definitions of terms. In other words, no specific definition was given for interpretive instruction. It was intended not to provide an exogenous influence in order to ascertain whether there is a natural affinity, based on individual experiences. BLV attributes were correlated to Servqual dimensions of Tangibles and Reliability. Tools and Methods were correlated at the same level for both Tangibles and Reliability dimensions. The relationship of Requirement Metrics fluctuated in magnitude but maintained the same relative position from that of Tools and Metrics for both the Tangibles and Reliability dimensions. These relationships and processes can be thought of as based on information that support traditional P/P management performance measures such as Earned Value. They also result in physical or digital models that describe the system being developed or its behavior. The balance of BLV attributes is considered intangible in that they are reflective of group behavior, and norms. Survey results indicate that Organizational Factors, Enterprise Relationships, and Leadership & Management dominate the remaining traits of Understanding, Communication, Access, Credibility, Courtesy, Competence, and

Responsiveness. The details of the correlation are shown in Figure 30. The percentages are the result of the number of respondents selecting the option divided by the total number of survey participants.

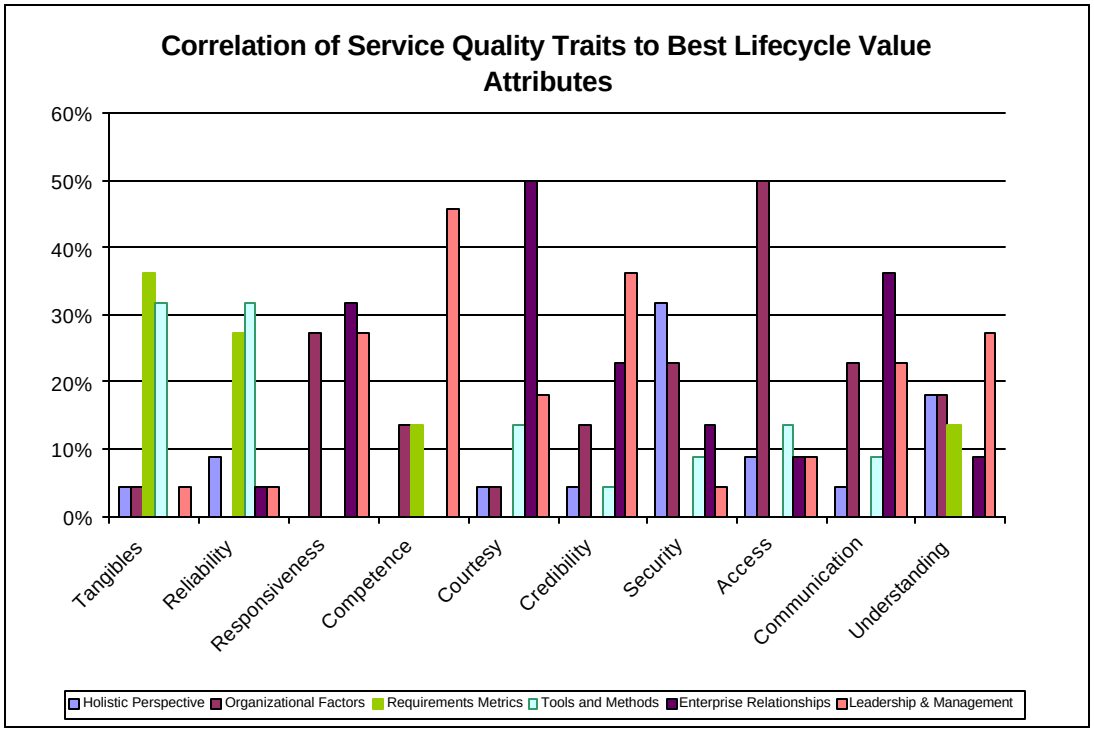

Figure 30 - Mapping of Servqual Model Dimension vs. BLV Attributes

5.5. Affinity Diagramming

The application of Affinity Diagramming resulted in three lobes representative of the information sources: Congressional Records review, Executive Interviews, and Survey/Case Study. [40] Common to all lobes is emphasis on strategic implications, the viability of the subsequent goals and objectives and commercialization. Each lobe is further detailed to identify its characteristics within the broad categories of competitiveness, commercialization, and strategic implications. The process was modified slightly. The elements were not formulated into a "what" statement, but were left as close as possible to the original statement structure and are shown in Figure 31. Subsequent Affinity Diagramming related information is shown in Figures 32, 33 and 34.

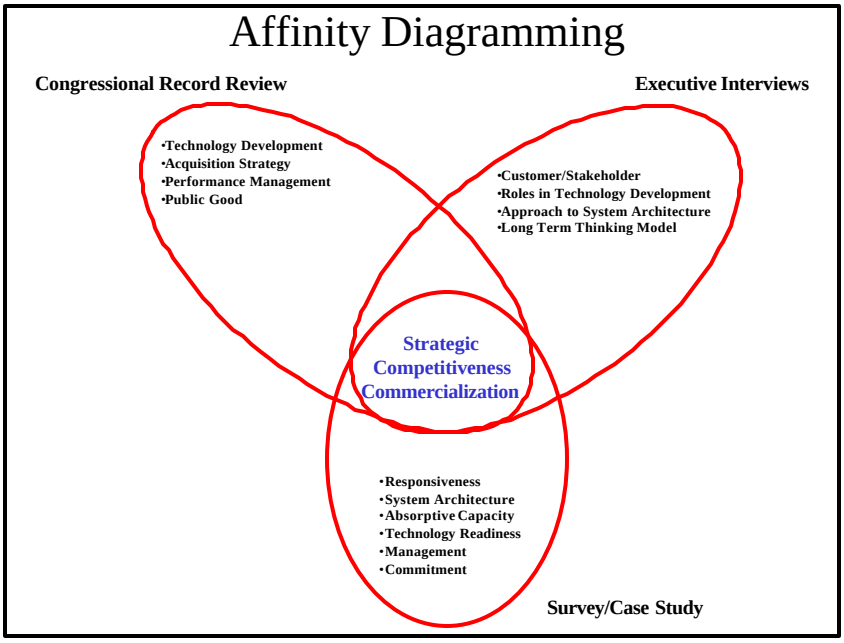

Figure 31 - Analysis Affinity Diagram

When considering the selected program cancellations, the Executive Interviews highlighted competitive concerns range from a lack of commitment (in terms of funding and leadership), to a set of goals and objectives. Further difficulties come as a result of discontinuities in the MOE (payload-cost-to-orbit and return on investment) in determining the value of these efforts. This discontinuity reflects differences in value from the perspectives of the stakeholder (the Government), the supplier (the Developing Agency), and that of the commercializing organizations (the Private Sector). It corresponds to Gap 1- Customer Expectations, Gap 3 – Service Performance, and Gap 4 – Promise and Delivery Mismatch, of the Servqual model. It resulted in programs being marketed as meeting certain customer parameters, but are completely under-resourced and under-performing. Details of the process associated with developing prioritizations for the diagramming element are shown in Appendix A.

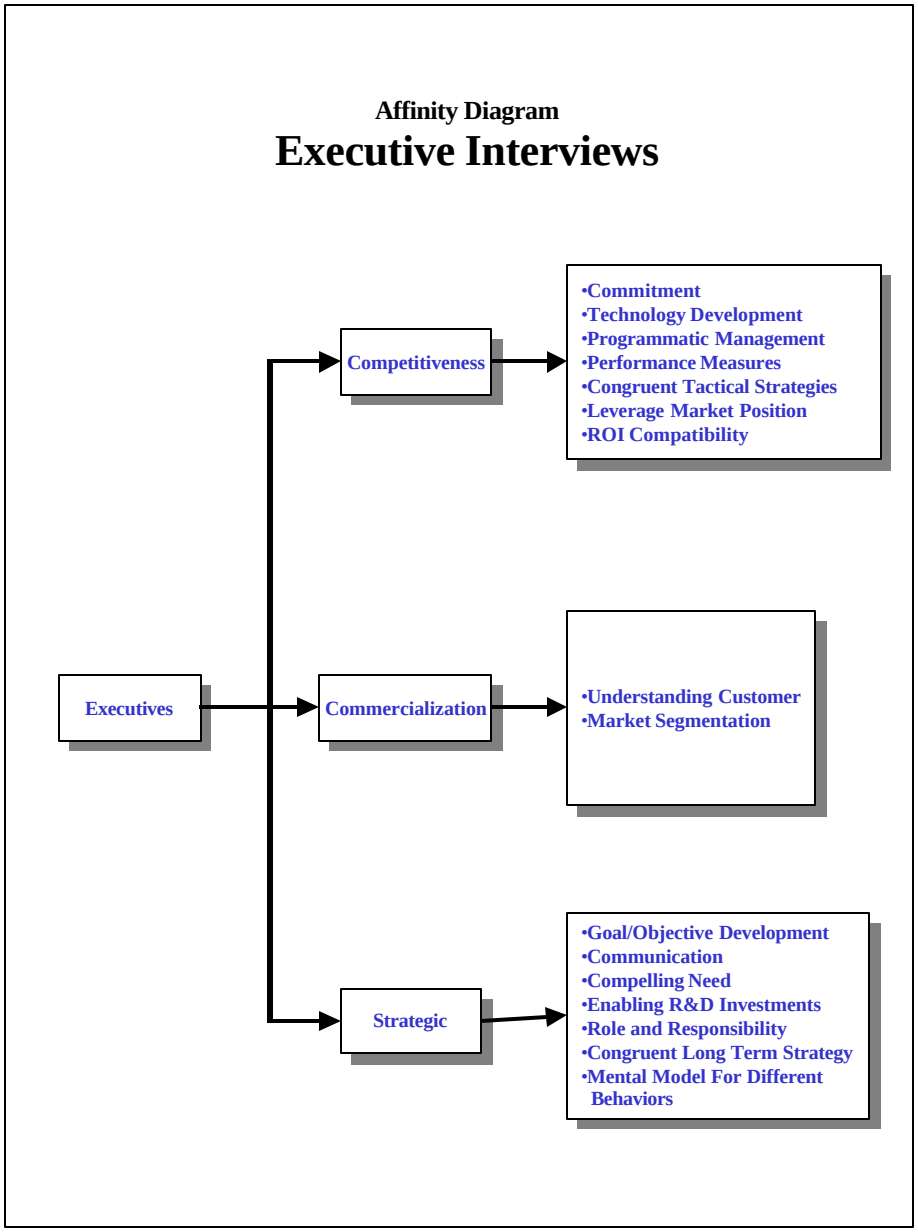

Figure 32 - Executive Interviews Affinity Diagram Categorization

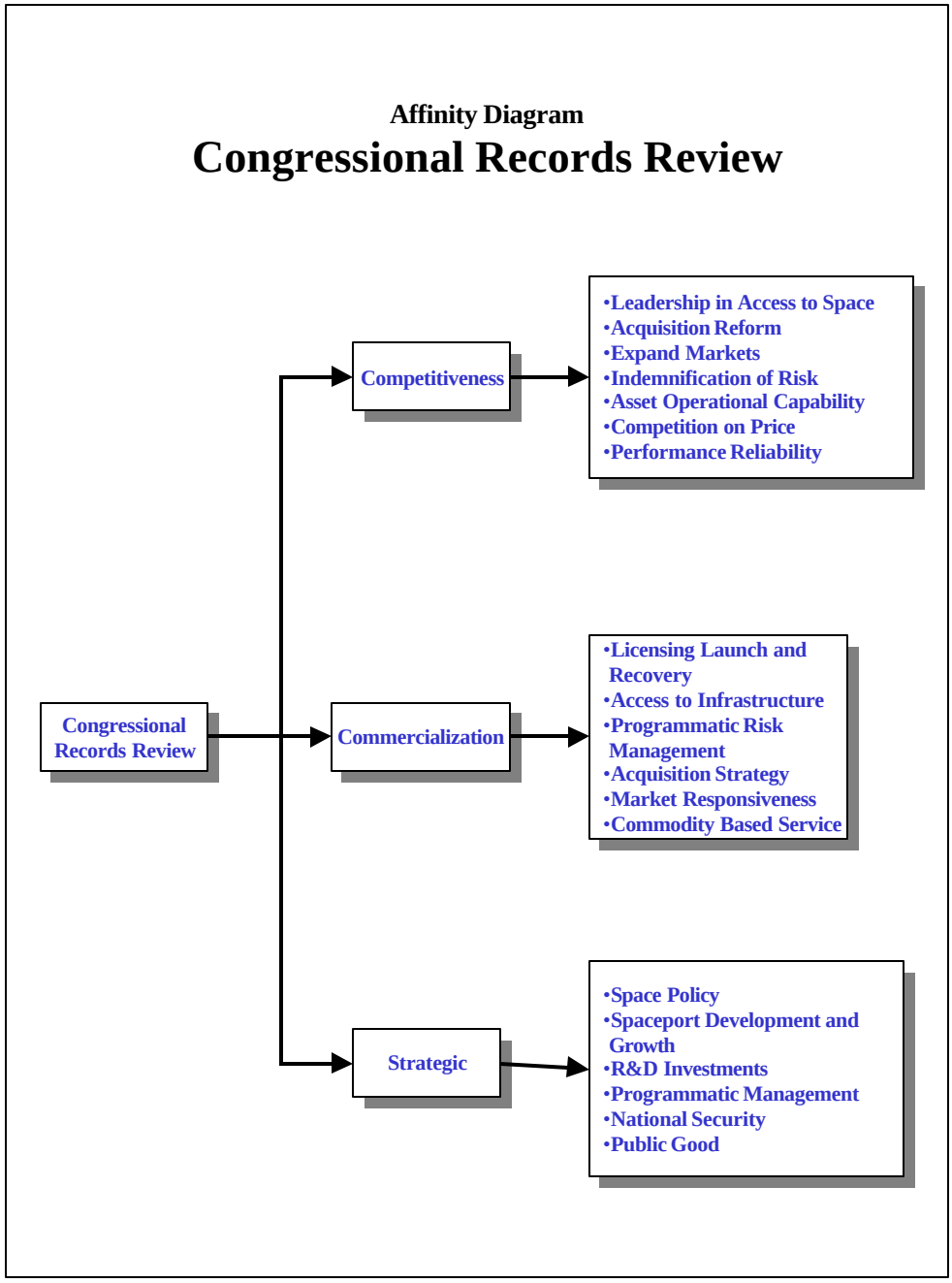

Figure 33 - Congressional Records Review Affinity Diagram

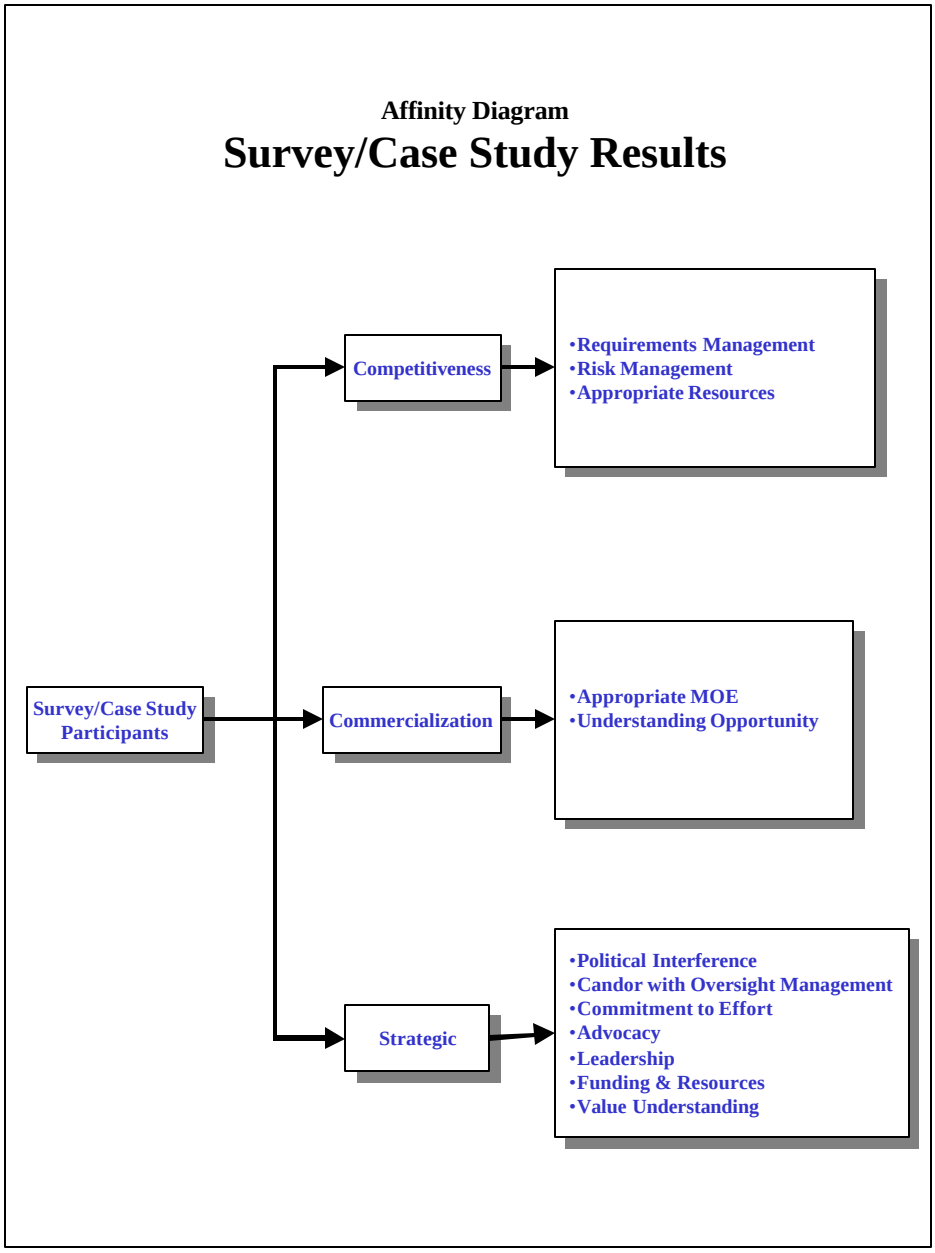

Figure 34 - Survey/Case Study Affinity Diagram

5.6. Quality Function Deployment Analysis

The Affinity Diagramming resulted in the coalescing of data within each of the three data sources. The QFD method is used to integrate the results and assigned values to understand the implications of the relationships between the data source categories and their respective elements. For

this analysis, the center items of Strategic, Competitiveness, and Commercialization are used as the goals. The elements of each of these categories are used to populate the "How's" matrix which will be correlated to the goals in the "What versus How" matrix. This matrix forms the center of the "House of Quality" shown in Figure 35. Additional information is used to establish relationships between the Product Development Values defined by Chase, and the goals identifie d previously. [17] The details of the QFD are provided in Appendix C. The numerical values that support the QFD are shown in detail in Appendix A.

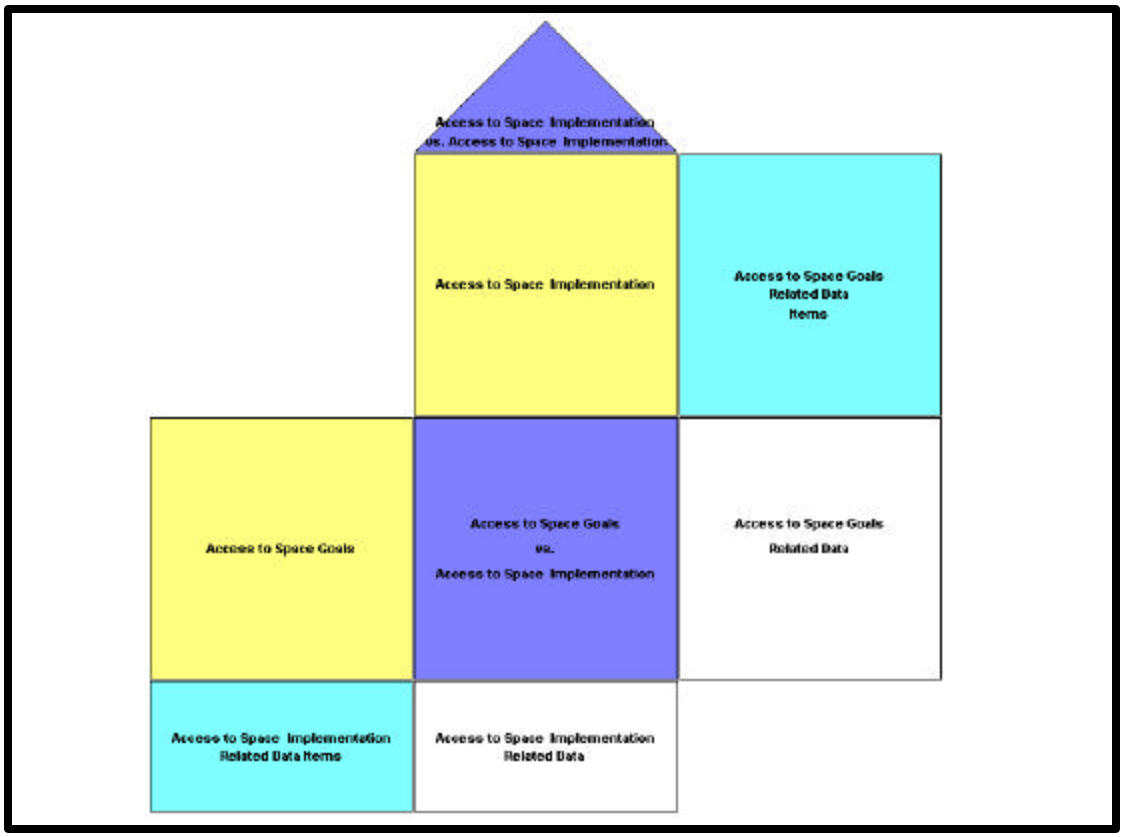

Figure 35 - Access-to-space House of Quality

The QFD resulted in the goals being prioritized in the order of Competitiveness, Strategic, and Commercialization. This ordering seems reasonable in that much of the launch services effort is still closely linked to national issues that indirectly influence competitiveness from a global perspective. Public Sector leadership desires to commoditize and commercialize its financial exposure as possible,

which better aligns with its methods of funding. However, this induces complications in terms of its real ability to actually commercialize much of its efforts.

When considering the correlation between the "What's" and "How's," the number one item was Customer Relationship Management, with a score of 7.75. This reflects an imperative desire, on the part of both the Government and the Contractors, to service one another. The roles are dynamic as the acquisition process and PD lifecycle are accomplished. Next, is the realization that complex system development, in the access-to-space market, must have market pull (score of 6.79) in order to be successful. Third, is the recognition that the strategies of the customer and supplier must be in agreement (score of 6.51) in order for partnering and cooperative relationships to result in successful efforts. Indemnification, appropriate MOE and return on investment compatibility, all tied with scores of 5.57 and reflect the notion that MOE's, used to determine success, must be commensurate with the situation and environment, and may indicate a need for the development and implementation of a more appropriate set of measures. This is also consistent with the concept of changing the mental models. [36]

Last of the top five is Requirements Management. This staple of solid P/P management is still recognized as critical to controlling cost and schedule, but more so for shoring up the communications effort.

The roof portion is where the implementation How's are reviewed for potential conflicts with other How's. This reflects only those situations where weak or strong conflict potential might exist. It resulted in two clusters: (1) stemming from the influence of organizational vision and behavior modification on a number of other How's that address goals/objectives, strategies and measures of performance and (2) represents the balance that must be maintained in order to be an effective and viable activity, when considering customer/stakeholder strategies and how well the P/P aligns with them. These are due to changes in organizational vision and behavior that would devalue existing knowledge and introduce risks associated with the customer/supplier relationship where assurances must be conveyed. In addition, how well the MOE and in particular profitability metrics, align to best provide insight to the situation or opportunity. All of this is contingent upon the customer/stakeholders' ability to establish and

convey the compelling need. This may not align well with the thinking of the suppliers and make for a difficult relationship.

When considering the Product Development Values developed by Chase, a correlation to goals in the order of activity efficiency, activity quality, communication, risk and information was shown. This also maintained the same goals priorities mentioned earlier. It is also consistent with the intent of the Servqual model where quality and efficiency should be dominant and the result of excellent communication, management of risk and utilization of information.

The competitive pressures portion looks at the competitors in the launch services market using information from Reference [28]. This data indicated a significant lead in launch services by the European Space Agency (ESA). Factors were developed to establish a relationship between the competitors relative to the goals derived from the data sources. The result is an improvement factor, which correlates the U.S. position to the leader, in terms of how much improvement is needed. The indications are that significant effort is required to reach par, relative to the goals of Competitiveness and Commercialization. Less effort is required when considering strategic issues.

The last section considers the specifics of implementing each of the 'How's." Portions of this section are intentionally left blank because solutions would be effort specific. The point is to recognize that issues exist and that the P/P teams should be well aware and take steps to look for solutions that fit their specific situation and environment, in which the development activity is occurring.

Chapter 6 will address the mapping of the analysis results to the development of the heuristic model and features proposed previously. It will also demonstrate correlation between the characteristics and traits of the P/P phase and the service management models.

Chapter 6 - Proposed Framework

The basis of the heuristic development is that value occurs at the interface, or in service terms, during the interaction between two parties. The conditions and events surrounding the interaction will dictate the quality and how it is communicated and perceived by both parties. In architecting complex systems, a principle, which states that value occurs at the interface, is used to demonstrate this point. [21] To formulate this into a framework, the NASA P/P Management Policy Guide 7120.5A, is used and clearly indicates that interactions with customers and stakeholders is required. However, the content of these interactions are not specifically defined. This is purposeful to allow flexibility for the P/P manager to tailor the interaction for maximum opportunity to succeed. These interactions will usually center on goals and objectives for a/the system(s), which closes the loop between the customer, stakeholder, and developing organization. Figure 36 shows the representation of the 7120.5A process and where the interfaces are influenced by Goals and Objective and the necessary effort to diffuse the system(s) out to the customer. A larger version of Figure 36 is shown in Appendix E

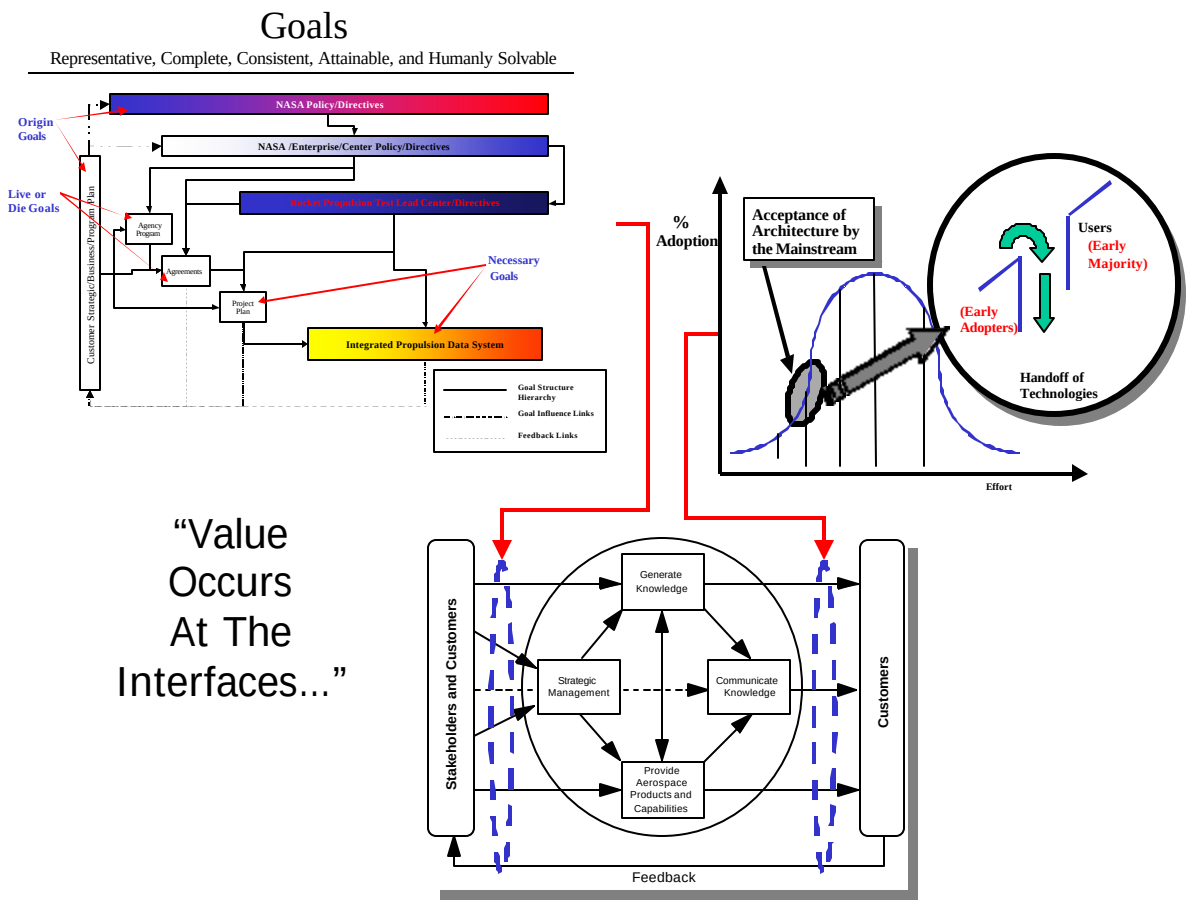

Figure 36 - Architectural Principle-Value at the Interface

The communications of goals that are complete, consistent, representative, and humanly solvable are critical to satisfying customer expectations and fostering a common understanding. From this, trust is developed and fruitful interactions can be nurtured. Value at the interface between customer and supplier of services, during this phase of development, can be expressed as shown in Figure 37. This relationship takes into account the tangible and intangible aspects of formulating strategies and processes necessary to

developing complex systems. This also includes the balanced communication of quality and MOE.

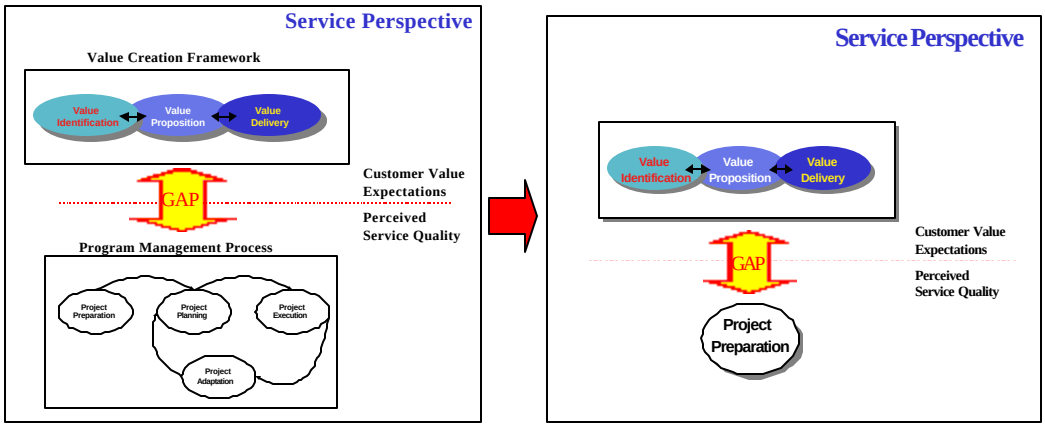

Figure 37 - Decomposition of BLV From Service Perspective to a Single Phase Application

6.1. Premise and Feature

The result of this attention will be the formulation of the notion that value is phase related and that Lean Thinking and Principles can be implemented in the P/P Preparation Phase. This recognizes that the softer issues of Lean implementation, where its products are largely intangible and subjective (in terms of quality and value) to customer interpretation, are critically important. The premise for this condition is stated below along with sub-features (F_n).

The premise is: Value in the P/P Preparation Phase is captured during the interaction between the Customer and the Supplier where the products are primarily intangible. Sub-Features are as follows:

F_1: The characteristics of the BLV are consistent with those of the Servqual Model.

F_2: The characteristics of the Servuction Model are applicable to the P/P Preparation Phase of the management process.

F_3: Value can be expressed in services terms.

Successful complex system P/P's have managed the expectations of the customer such that the perceived service quality and value are commensurate with customer expectations. In lieu of tangible items (hardware, software, simulations, etc.), to demonstrate understanding, appropriate levels of reliability, responsiveness, assurance, and empathy are delivered to the customer as intangibles. This, in

turn, communicates a consistent message of quality that parallels the decision-making processes. The back office capabilities perform architectural and systemic analyses (cost and technical), while meeting expectations of quality and desired timing.

6.1.1. Feature 1

The characteristics of the BLV are consistent with those of the Servqual Model.

The platform for success within the P/P Preparation Phase is shown in Figure 38. Survey participants indicated the ability to communicate is the most critical trait and is closely followed by trust, reliability, and accuracy of information, as being very important. While low, relative to other dimensions, relationship management is considered most important to successful execution of this phase. This is consistent with the service management characteristic of Heterogeneity/Variability, which addresses the ubiquity and ambiguity of the interaction between the customer and the supplier. The results of the above reflect agreement between Servqual dimensions and BLV attributes and are shown in Figure 39.

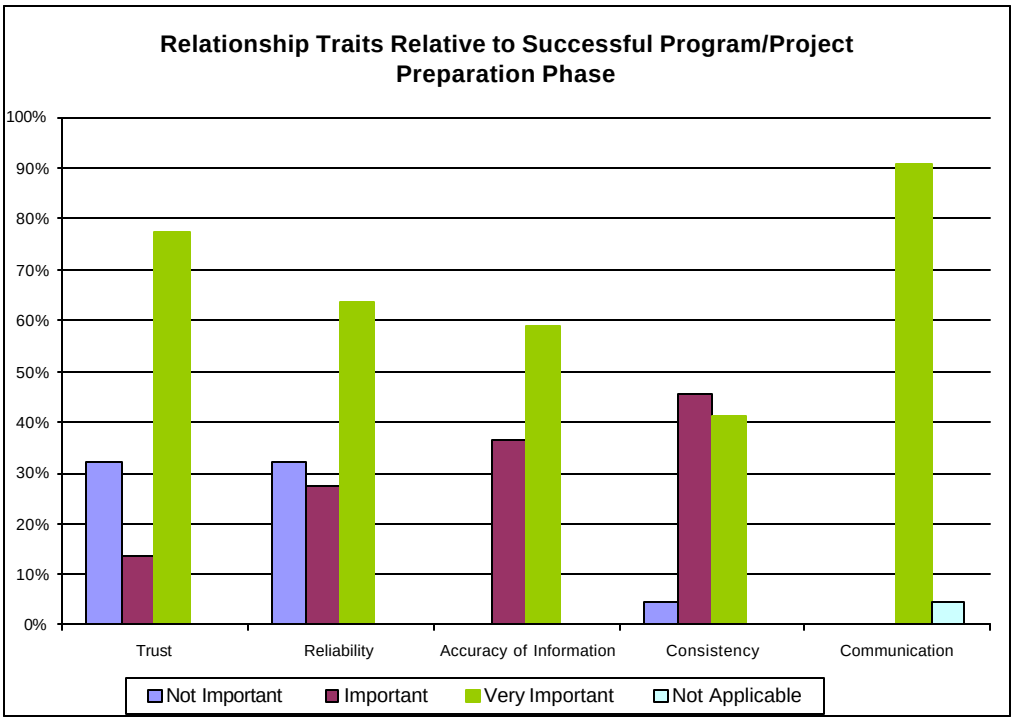

Figure 38 - Relationship Traits for Success in the P/P Preparation Phase

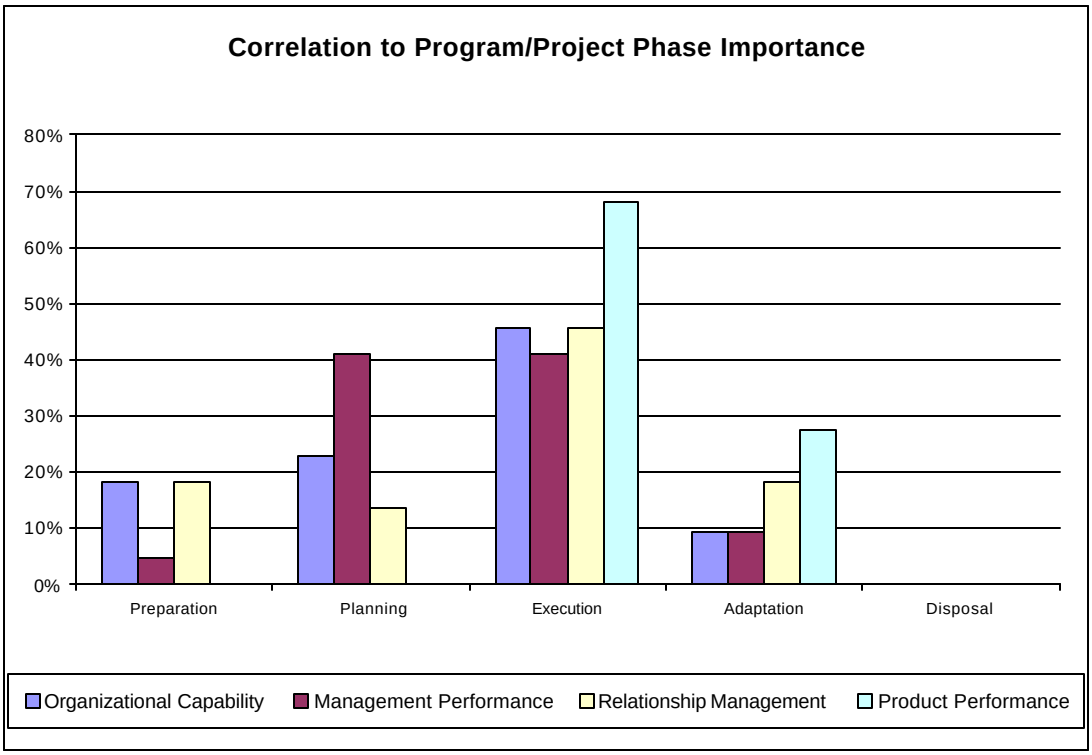

Figure 39 - Program/Project Phase Importance

6.1.2. Feature 2

The characteristics of the Servuction Model are applicable to the Program/Project Preparation Phase of the management process.

The Case Study of Access-to-space system development activities reflected cancellation of systems because of over-promising on capability, and discontinuity in MOE associated with launch rates, return on investment, operations costs, and technology readiness. All are summarized in Table 4 in Section 5.3. The Blueprinting aspect of the Servuction framework is similar to typical steps taken to address P/P uncertainties and planning. These uncertainties include, but are not limited to, risk analyses, which support the application of decision theory and require a thorough understanding of the systemic behavior of the P/P. Tools and Methods are the mechanisms used to perform the Blueprinting and their importance is reflected in Figure 30 in Section 5.4, according to the survey.

These efforts attempt to "tangibilize" the products and remove ambiguity that naturally surrounds the process. This tangibilization takes the shape of reports that communicate assurances and describe the

system architecture that is representative of the communicated goals and objectives. As P/P time moves along, the service relationship changes, in terms of knowledge acquired and the tangible portion of the interaction increases. This implies that the appropriateness of earlier interactions and products are diminishing in value and are perishable in terms of the phase. It also implies that interactions and products addressing downstream events are less in value but are applicable as time moves forward.

6.1.3. Feature 3

Value can be expressed in services terms.

Using the expression defined in Section 1.5.4 (Equation 1), Customer value can be subdivided into elements that address service and strategy components of the phase. The first element addresses the cost of the product in terms of information and metrics. The second part is the strategic portion that addresses the customer's perception of the quality of the service via proven reliability, assurances, and demonstrated leadership. Associated with this is the cost of acquiring the service and customer internal processes that leverage the value in a meaningful manner. These relationships are reflected in Equation 2.

$$\textit{Customer Value} = \underbrace{\frac{\text{Results Produced for Customer}}{\text{Price to the Customer}}}_{\text{Service}} + \underbrace{\frac{\text{Process Quality}}{\text{Cost of Acquiring the Service}}}_{\text{Strategy}}$$

Equation 2 - Customer Value Expressed in terms of Service and Strategy

Considering Equation 2 and the definition of customer value from a service perspective, it appears consistent with the customer value relationship shown in Figure 40. Both address product, service, cost of acquisition, timing, and overall quality of the product and process. Figure 40 was demonstrated to be consistent with Lean Thinking criteria of a specific product, price, and time in reference [19]. This is consistent with service attributes of Inseparability and Perishability. Therefore,

based on the logic of the mathematical axiom of Transitive Property of Equality,[8] it is reasonable to infer that Equation 2 is consistent with Lean Thinking.

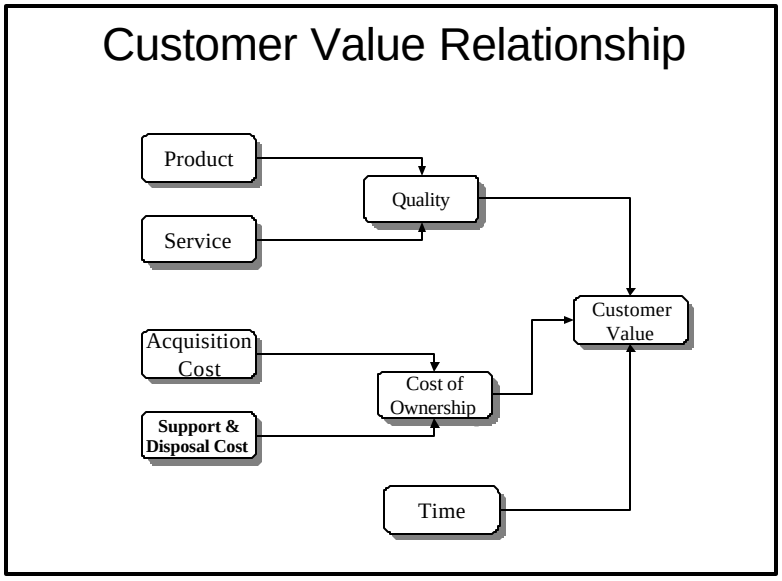

Figure 40 - Customer Value Relationship (adopted from [19])

Inseparability is manifested through the interaction between the customer and the supplier when the service is delivered by the supplier and consumed by the customer. In the P/P Preparation Phase, this occurs during interactions where the P/P is measured against a set of goals and objectives and MOE that communicates trust, reliability, and assurance. This represents the service portion of the customer value equation shown in Equation 2. The strategy portion is when the customer assesses how well the results integrate with its infrastructure. The cost of the integration is perceived to be acceptable. Perishability is also manifested through the consideration of timing, the same as in section 6.1.2.

[8] For any numbers a, b, and c, if a=b is true and b=c is true, then a=c is true.

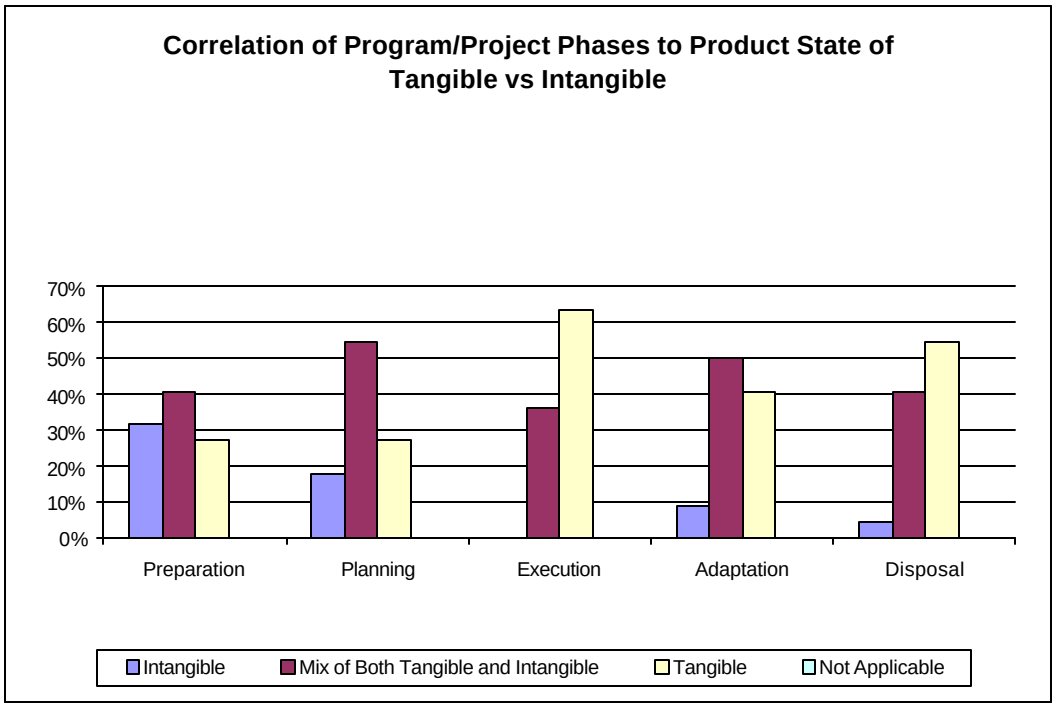

Figure 41 - P/P Phase Product Correlation.

The concept of phase-related value is based upon acceptance of the notion that Equation 2 is a valid representation of value in Lean Thinking and Principles terms. This includes the characteristic of Perishability and Heterogeneity/Variability, which correlates to timing, as noted by Slack. Therefore, using the logic of the mathematical axiom of The Distributive Law of Multiplication over Addition, it is reasonable to apply the Value Creation Framework on a P/P Phase-related basis. This is consistent with the survey results shown in Figure 41 and Figure 39 of Section 6.1.1.

6.2. Gap Correlation

By managing the Servqual model gaps of expectations, perceptions and consistent communication, perceived value is delivered given the fact that no system hardware exists. The case study on Access-to-space was used to develop corresponding Gap management issues for the cancelled programs. Additional insight was applied from the executive interviews and review of Congressional records. The relationships used for this correlation are those conditions where the Private Sector is providing services to the Government, and Congress is playing the role of customer/stakeholder. The

other scenario is the condition where the Government is providing services to the Private Sector and Congress is playing the role of stakeholder (to a lesser influential position). For the systems considered, the end user is usually not the recipient of the services provided. The Gaps address Customer Expectations, Quality Standards, Performance, and the Mismatch between Promises and the Delivery Service. Details of these correlations can be found in Appendix D.

6.2.1. Gap – 1, Customer Expectations

Gap-1 issues included inconsistencies in goals and objective setting that lead to discontinuity between the expectations of the customer/stakeholder and perceptions of quality provided by the supplier of the services. Using reports and other secondary means of contact, manager's understanding of customer reality can fall short of the desired mark. This is especially true of organizations like the U.S. Government and the convoluted role it plays as customer and stakeholder. The lack of direct interaction with the Developmental Agency P/P team and general public further complicates the relationship and the issues that make this Gap difficult to close. Developmental Agency P/P managers and their support contractors are disadvantaged in that interactions with its powerful customer/stakeholder (Congress) are akin to command performances and usually are negative in purpose. They are further disadvantaged by the fact that communication is via secondary monitoring organizations (e.g., Congressional Committees, OMB, OIG, GAO, etc.)[9]. This naturally allows the potential for a confrontational relationship (e.g., if the P/P Manager or management team is not a strong and seasoned). The P/P team must remain sensitive to customer/stakeholder needs variation in order to be responsive, given the dynamics of the political environment. Hence, success is not based on technical correctness or accuracy, but on perceptions and votes. A summary is shown in Figure 42.

[9] Office of the Inspector General (OIG), Office of Management and Budget (OMB), Government Accounting Office (GAO)

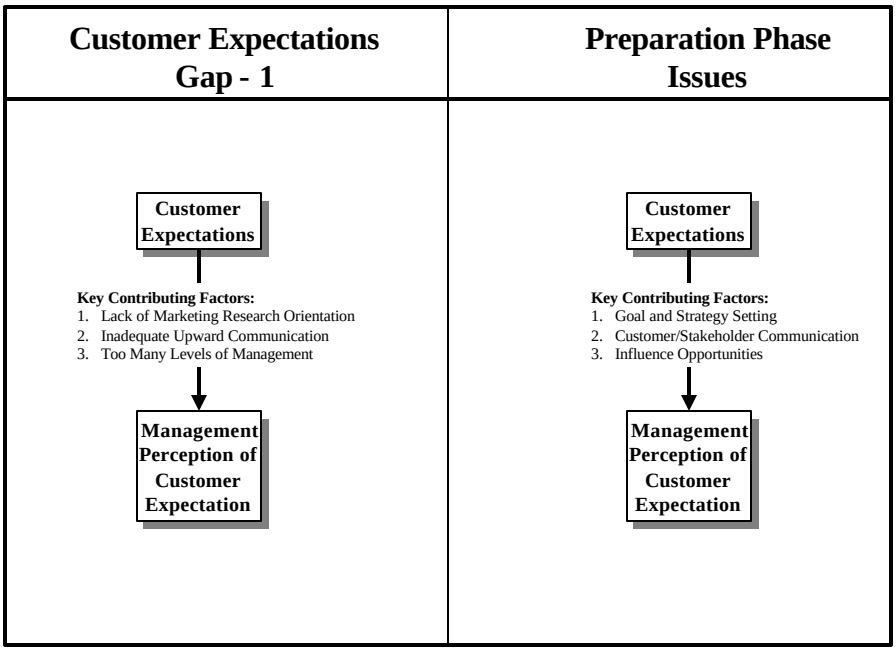

Figure 42 - Gap-1 Customer Expectation

6.2.2. Gap - 2, Service Quality Standards

Gap-2 issues address quality standards and reflect the conflicts that organizations must face in balancing commitment to quality, while other efforts focus on cost reductions or short-term profits, to identify a few. Considering the cancelled Launch Vehicle systems of the case study, most suffered from a lack of commitment to purpose by the U.S. Government (changing Developmental Agency priorities and P/P Manager rotation). Perceptions of feasibility become a balancing act that requires candor to report the result of incompatibility between stakeholder allocations of resources and agreement upon goals/ objectives and MOE. Infeasibility in meeting these needs can be attributed to shortsightedness on the part of both P/P Managers and customer/stakeholders. In the case of the developing Agency managers and their contractor support team, infeasibility comes as a result of the limitations of the funding strategy and the tug-of-war for limited resources based on social and political dynamics.

Service quality, in terms of access, demonstrated competence, and reliability, can be achieved through implementation of technologies. In this case, soft technologies seem more appropriate in that the traits mentioned above are achievable through technologies such as web-portals, virtual private networks

and data warehouses. Hard technologies (usually by third party reporting through testimonies) are reflected in existing systems that provide insight to budgetary information that support the utilization of MOE. A summary is shown in Figure 43.

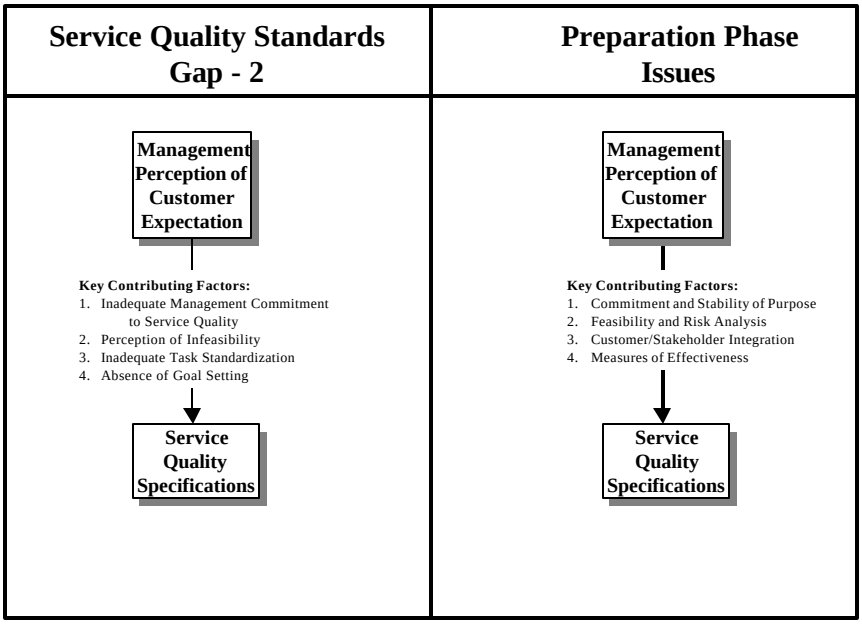

Figure 43 - Gap-2 Quality Standards

6.2.3. Gap – 3, Service Performance

Gap-3 deals with Service Performance and how it is influenced by commitment from the perspective of the employee and management, as well as that of the role technology and management systems play in the delivery process. Information management and associated technologies are important in maintaining information flow to the customer/stakeholder. However, success tends to be on a P/P by P/P basis versus across P/P's, within a developmental Agency, or across developmental Agencies.

Recent cancellations of the X-33/34 programs, both of which used cooperative relationship CPP as a part of the acquisition strategy, demonstrates the impact of reneging in this relationship. [39, 26] The survey data indicated experience with CPP is low, and therefore, it is reasonable to assert that implementation risk exists for such a strategy and would be higher than normal. Also the data shows this kind of CPP strategy is primarily associated with meeting Political needs, yet the programs were

purportedly cancelled because of performance and technology issues. The stakeholder position of Congress and associated dynamics of the political environment is of importance to development Agencies like NASA. Understanding this interaction is part of the development of P/P Managers and is a part of the formal training provided. [41]

An example of role conflict would be the nest of Government Agencies requiring interaction in order to launch a payload in the U.S. As many as four different organizations are involved with the licensing and operations of U.S. launched payloads. This is because the active Spaceports that are on Government reservations and that are leveraging the existing infrastructure. Once other Spaceports are opened, can the opportunity to reduce the number of interfacing organizations exist?

Supervisory control is difficult to execute because of the dynamics involved and the ever-decreasing time to adapt to situations. From the survey, indications were that P/P Leadership is not consistent across development efforts. As a result, it is difficult to measure the true output of the P/P Leadership. Sometimes the successes or failure are incremental in nature and can be attributed to a single event. However, considering the International Space Station and its $400 Million overrun, this accounts for both incremental success and failure, and is a victim of the dynamics associated with the political process. [42] A summary is shown in Figure 44.

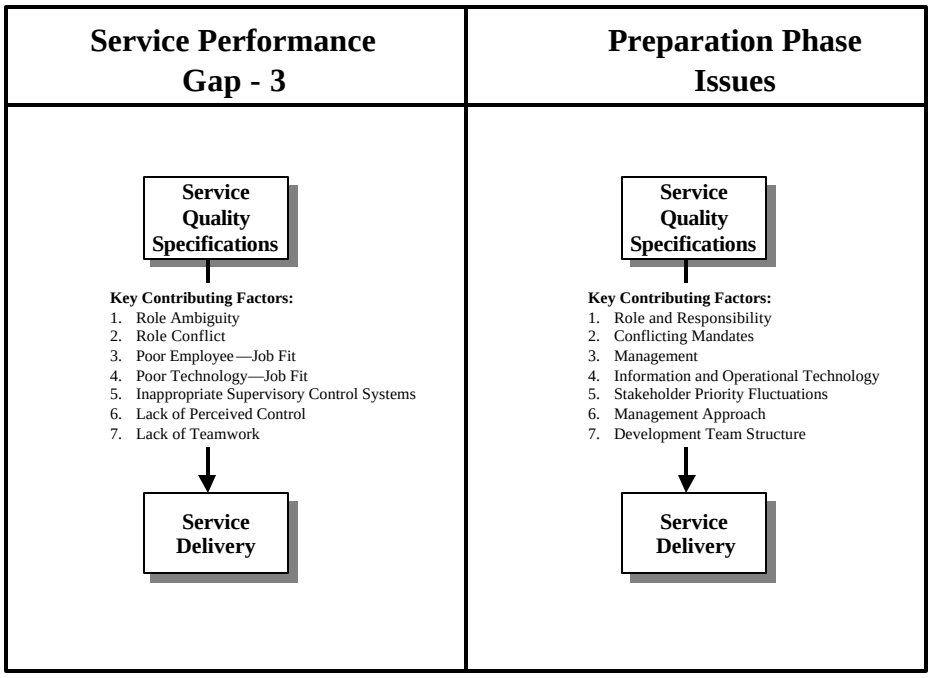

Figure 44 - Gap-3 Service Performance

6.2.4. Gap – 4, Promise and Delivery Mismatch

Gap-4 deals with consistency in the message being communicated to the customer/stakeholder and the quality of services delivered. This includes horizontal communication within the development Agency as well as across developing agencies. It also includes consistency in the message and the end state of the system being developed. NSTS is the perfect example of this gap. It was advertised as 60 flights per year, but only realized six[10]. A summary is shown in Figure 45.

[10] A large portion of the reduced capability is due to customer/stakeholder reductions in resources that lead to reductions in capability and long-term operational cost savings. [4]

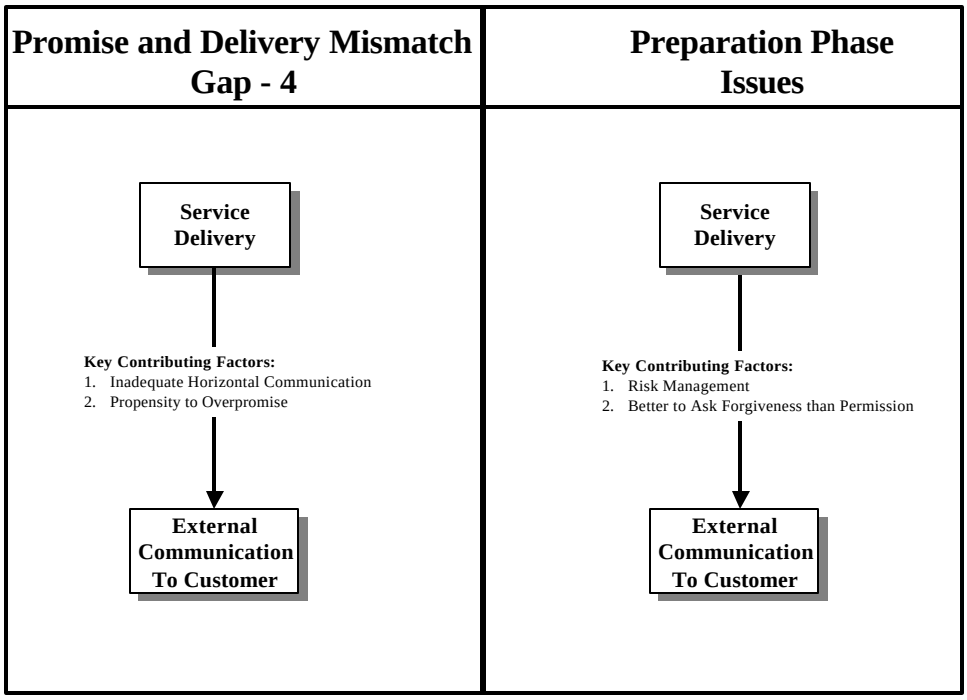

Figure 45 - Gap 4 Promises and Delivery Mismatch

6.2.5. Gap – 5, Sum of Gaps 1 thru 4

Figure 46 is provided to bring together the conditions that exist at the gaps, dimensions of the service quality model and their relationship to the P/P PP. Furthermore, Figure 46 has been annotated with survey data to reflect the correlation, to service quality dimensions. It shows that Requirements Metrics (36%) relates to efforts to "tangibilize" the intangible aspects of the interaction. Tools and Methods (32%) relate to the demonstration of reliability during the interaction. Enterprise Relationship relates to the organization's ability to be Responsive (32%) to the needs of the customer, and the conveyance of Assurance (29%). Empathy, which is a collection of Access, Communication, and Understanding, is related by Organizational Factors (30%) to the quality of the interaction between the customer and supplier.

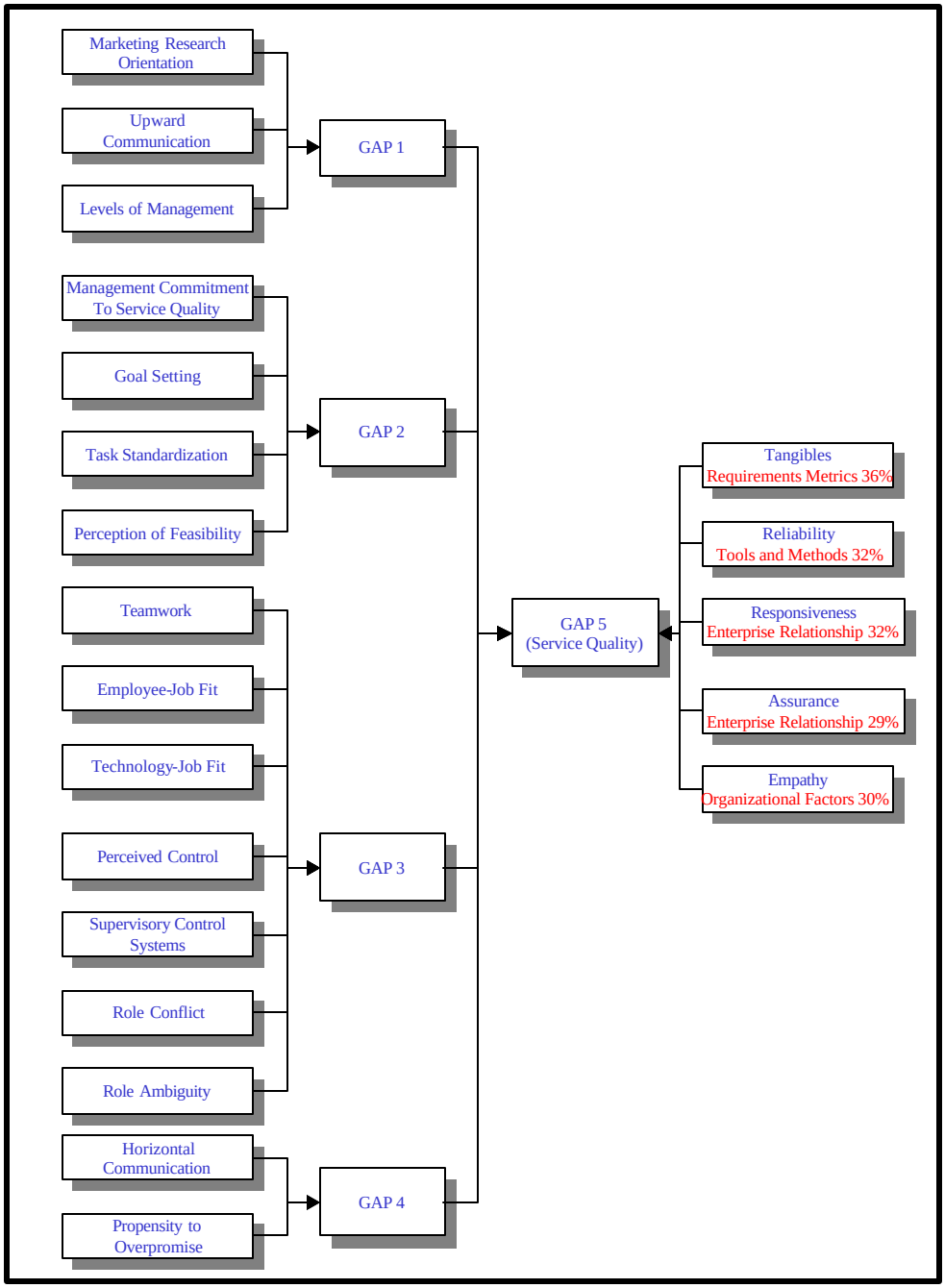

Figure 46 - Gap-5 with BLV Mapping

6.3. Summary

The P/P Preparation Phase exist for the purpose of coalescing ideas, concepts, and goals into a cohesive set of behaviors and processes that result in a product that the customer/stakeholder find valuable. The previous sections bring together the notion that this phase of complex system development can be managed using the frameworks of the service management industry. This is of particular importance when considering the access-to-space infrastructure and its repeated efforts to develop new systems. The majority of the efforts undertaken failed to mature beyond the early stages of the development lifecycle. Consequently, the systems employed today are based on Post WWII ballistic missile, staged architectures.

Stanke and Slack demonstrated what constitutes value throughout the PD lifecycle. Both resulted in frameworks and models that are well grounded in Lean Thinking and Principles, but do not address a phase-based relationship to value. Given the case study of U.S. access-to-space vehicle development cancellations, there is need to better understand value as a function of PD phase. Obviously, value of the end product was recognized and viewed sufficient to make resources available to support the initiation of a development effort. However, with so many cancellations, in such a relatively short time frame, indicates that value is not solely based on the end product, but is phase related once the overall concept value is accepted. Therefore, the Value Creation Frame Work presented by Stanke is reasonable for phase-based application. [8, 19]

Slack introduces the concept of customer value relationship, which brings aspects of quality, cost, and timing to bear on the PD lifecycle. Slack's perspective on Lean value in the PD lifecycle captures Quality via the product or service itself, cost in terms acquisition and support costs and finally timing in terms of market conditions. [19] This thesis brings these two concepts together and applying them to the P/P Preparation Phase. Then adding the notion of value being phase related, brings to mind the concept that a "gap" exists between these approaches to value and the phases of the PD lifecycle. Subsequently the question arises of how can these two concepts of value be related such as to afford the greatest opportunity for success during the P/P Preparation Phase.

The "gap" between the Value Capture Framework and the phases of the PD lifecycle can be viewed as service oriented and managed via the application of Management of Services models. These models provide a framework that embraces the intangible nature of the products resulting from the P/P Preparation Phase. Primarily the Servqual model provides a methodology for understanding and managing the " gap" between customer expectations and the perceptions of service quality provided by the supplier. The management of the "gap" includes significant efforts to understand customer needs and the system that will deliver the service. The model further address identified "gaps" in customer expectations and supplier perceptions via customer expectations, service quality, service performance, and consistencies in product and the message delivered to the customer. [9, 11]

The cancelled programs come as the result of perceptions that the need or conditions had changed or that exogenous decisions have had negative impact on the development effort. This is consistent with the Rechtin, Maier heuristic approach mentioned earlier, which states, "it's not the facts, it's the perceptions that count", and that critical issues must be transparent to the political elite.

This thesis has demonstrated that the P/P Phase can be managed using Management of Services models and techniques. It also emphasizes that the products during this phase are both tangible and intangible and that the interaction between the customer and the supplier is where value is captured. As a result, a different set of behavioral emphasis, (including modes of communication, the relationship of "back-office" activities to overall quality) and recognition of the importance to managing the customer/supplier relationship. Table 5 summarizes P/P Preparation Phase traits (that reflects the bi-directionally, U.S. Government/Developing Agency/Contractor relationship) and relates them to the dimensions of the Service Quality Model.

Table 5 - Servqual Model Dimension & Phase Trait Mapping

Servqual Model Dimensions and Definition [11]		**Program/Project Preparation Phase**
Dimension	**Definition**	**Traits**
Tangibles	Appearance of physical facilities, equipment, personnel, and communication materials.	Models, simulations, reports generated by the P/P
Reliability	Ability to perform the promised service dependably and accurately.	Well thought out and consistent in approach; Meeting programmatic and system MOE's
Responsiveness	Willingness to help customers and provide prompt service.	Timely responses to inquiries and testimonies; performance against MOE
Competence	Possession of the required skills and knowledge to perform the service.	Stable P/P leadership, OIG, OMB and other independent reviews, programmatic and technical performance
Courtesy	Politeness, respect, consideration, and friendliness of contact personnel.	Organizational culture manifested during interactions
Credibility	Trustworthiness, believability, honesty of the service provider	Organizational culture manifested during interactions
Security	Freedom from danger, risk, or doubt	Communication and Management of Uncertainty in the effort as well as mitigation approach
Access	Approachability and ease of contact	Organizational Leadership and Management approach that incorporates open communication
Communication	Keeping customers informed in language they can understand and listening to them.	Frequent interaction using appropriate MOE
Understanding the Customer	Making the effort to know customers and their needs.	Congruency of implementing strategies and appropriateness of MOE

Chapter 7 - Follow-on Activities

The work of this thesis is by no means exhaustive. As a result, opportunities exist for additional study. Several have been identified and are briefly addressed in the following paragraphs.

Two Schools of Thought on Applying the Value Capture Framework

The wiser approach to presenting this section is to start with that which is common in the schools of thought:

1. The interaction between the customer and supplier during any of the phases of P/P management depends significantly on what are called "soft" issues. These issues include communication, impressions, expectations, and feelings of assurance, demonstrated competence, and reliability.
2. Especially during the Preparation Phase, the issues of item 1 are paramount because of the lack of time and other resources to generate tangible and meaningful results that can be used as MOE. This is critical when considering complex systems that have long preparation and planning phases, before significant resources have been expended to support the generation of discernable MOE and hardware products.

The two schools differ in the ideas surrounding the application of the Value Creation Framework to the P/P management cycle. One thought proposes that the interaction between these two models is more "stovepipe" as shown in Figure 47. Then, applying the Management of Services concepts to the "gaps" that should be managed, as part of the interaction between the customer and supplier, are actually between specific phases of the process versus the entire process as shown in Figure 2 in Section 1.3. This school of thought would have the value identification process linked only to the Preparation Phase; the value proposition process linked only to the planning stage; and finally, value delivery linked only to the execution and adaptation phases.

Follow-on work could center on the development of detailed mathematical proof(s) of the logic employed in substantiating the phase-based relationship between the Value Creation Framework and the Program/Project Phases.

LAI Application of the Value Creation Framework

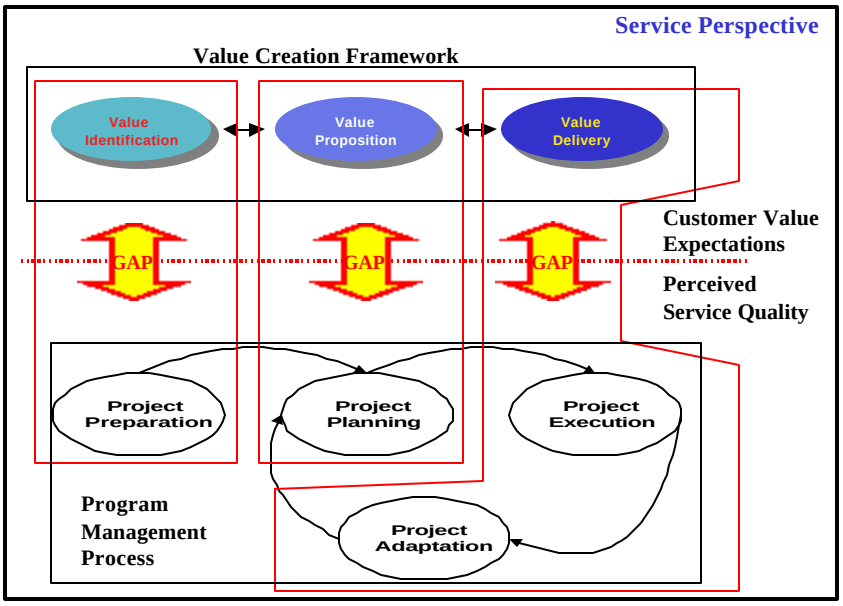

Figure 47 - LAI Application of the Value Creation Framework

Obvious extensions of this work would be improving on the methodology for gathering data to better corroborate the heuristic and strengthen the correlation of the two models. Additional and better data would improve the Affinity Diagramming and QFD efforts. Further effort could be applied to expounding on the mathematical relationship that supports this heuristic.

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Appendix A - Affinity Diagramming Prioritization

The following Tables and Figures reflect the calculations and resulting value used to populate the House of Quality associated with the application of QFD for this thesis. The "What versus How" matrix is populated with values derived according to Tables 7 through 9. Category weights were assigned using the results shown in Figures 31, 32, and 33 and are shown in Tables 7 through 9.

Table 6 - Affinity Diagram Category Prioritization

	Competitiveness	Commercialization	Strategic
Executive Interviews	2	1	3
Congressional Records Review	1	2	3
Survey/Case Study	3	2	1

Tables 7 through 9 come as the result of again, frequencies and categorization according to Table 6. The "What versus How" Weight value are the result of multiplying the importance value by the category weight value.

Table 7 - Weighting Factors for Executive Interviews [11]

Affinity Diagram Element	Frequency	Bin	Importance	Category Weight	"What/How" Weight
Commitment	1	0-2	1	1	1
Communication	1	0-2	0.3	3	1
Enabling R&D Investments	1	0-2	0.3	3	1
Mental Model for Different Behaviors	1	0-2	0.3	3	1
Programmatic Management	2	0-2	0.5	2	1
Congruent Tactical Strategies	2	0-2	0.5	2	1
Leverage Market Position	2	0-2	0.5	2	1
Market Segmentation	2	0-2	1	1	1
Technology Development	3	3-4	1.5	2	3
Performance Measures	3	3-4	1.5	2	3
ROI Compatibility	3	3-4	1.5	2	3
Goal/Objective	3	3-4	1	3	3

[11] Derived from six interviews [2, 23, 36, 43, 44, 45].

Development					
Compelling Need	3	3-4	1	3	3
Role and Responsibilities	3	3-4	1	3	3
Congruent Long Term Strategies	4	3-4	1	3	3
Understanding the Customer	5	5-6	3	3	9

Table 8 - Weighting Factors for Congressional Records Review[12]

Affinity Diagram Element	Frequency	Bin	Importance	Category Weight	"What/How" Weight
Leadership in Access-to-space	1	0-2	1	1	1
Acquisition Reform	1	0-2	1	1	1
Asset Operational Capability	1	0-2	1	1	1
Access to Infrastructure	1	0-2	0.5	2	1
Spaceport Development and Growth	1	0-2	0.3	3	1
Expand Markets	2	0-2	1	1	1
Performance Reliability	2	0-2	1	1	1
Acquisition Strategy	2	0-2	0.5	2	1
National Security	2	0-2	0.3	3	1
Indemnification of Risk	3	3-4	3	1	3
Commodity Based Service	3	3-4	1.5	2	3
Programmatic Management	3	3-4	1	3	3
Public Good	3	3-4	1	3	3
Competition on Price	4	3-4	3	1	3
Licensing Launch and Recovery	4	3-4	1.5	2	3
Programmatic Risk Management	4	3-4	1.5	2	3
Space Policy	4	3-4	1	3	3
R&D Investments	4	3-4	1	3	3
Market Responsiveness	5	5-6	4.5	2	9

[12] Derived from seven Congressional Reports [46, 47, 48, 49, 50, 51, 52]

Table 9 - Weighting Factors for Survey/Case Study[13]

Affinity Diagram Element	Frequency	Bin	Importance	Category Weight	"What/How" Weight
Funding and Resources	1	0-2	1	1	1
Political Interference	1	0-2	1	1	1
Commitment to Effort	1	0-2	1	1	1
Appropriate MOE	2	0-2	0.3	3	1
Understanding Value	2	0-2	0.3	3	1
Advocacy	2	0-2	1	1	1
Value Understanding	2	0-2	3	1	1
Candor with Oversight Management	3	3-4	3	1	3
Risk Management	4	3-4	1.5	2	3
Appropriate Resources	4	3-4	1.5	2	3
Leadership	4	3-4	3	1	3
Requirements Management	5	5-6	4.5	2	9

Table 14 reflects the categorization of the elements of the Affinity Diagramming effort and relating them to PD Value Categories for later use.

Table 10 - Correlation of How's to PD Value Categories

Correlation of How's to PD Value Categories	
How's	**PD Value Category**
System Safety & Reliability	Q
Risk management	I
License Civil Space Ports (Launch & Recovery)	E
Market Pull (Segmentation, Responsiveness, Position, Share)	Q
Indemnification	R
Systems (Vehicle, Facility, & Support) Operations	E
Acquisition Reform	E
Commodity Based Services	E
Technology Development	I
Leadership/Commitment	C
Acquisition Strategy	R
R&D Investment	E
National Security	R
Programmatic Management	C

[13] Derived from Appendix B Survey (2) and (3) data, Questions7 and 8.

Public Good	Q
Communication	C
Organizational Vision and Behavior Modification	C
Congruency of Strategies	R
Appropriate Measures of Effectiveness	I
ROI Compatibility	C
Goals/Objectives Development Process	C
Compelling Need	Q
Roles & Responsibility	E
Customer Relationship Management	E
Access to Infrastructure	E
Space Policy Development	Q
Appropriate Funding and Resources	E
Political Interference	R
Value Understanding	Q
Requirements Management	Q

Table 11 is the result of element correlations to PD Value attributes, as shown in Table 10. This count is reduced to a percentage for later use.

Table 11 - How vs. PD Frequency Distribution

How/PD Correlation Percentage	Frequency	Percent
Quality	7	0.23
Efficiency	9	0.30
Information	3	0.10
Risk	5	0.17
Communication	6	0.20
Sum	30	

Table 12 is derived by the count of elements in each of the Goals from the three sources of data. This count is multiplied by the PD Value percentage shown in Table 11. This is repeated for each of the Values and Goal groups.

Table 12 - Correlation of PD Value Attributes to Data Goals

Correlation of PD Value to How elements						
Executive	**Frequency**	**Quality**	**Efficiency**	**Information**	**Risk**	**Communication**
Competitiveness	7	1.63	2.1	0.7	1.17	1.4
Commercialization	2	0.60	0.6	0.2	0.33	0.4
Strategic	8	0.80	2.4	0.8	1.33	1.6

Congressional Record	**Frequency**	**Quality**	**Efficiency**	**Information**	**Risk**	**Communication**
Competitiveness	7	1.63	2.1	0.7	1.17	1.4
Commercialization	6	1.40	1.8	0.6	1.00	1.2
Strategic	6	1.40	1.8	0.6	1.00	1.2
Survey/Case Study	**Frequency**	**Quality**	**Efficiency**	**Information**	**Risk**	**Communication**
Competitiveness	3	0.70	0.9	0.3	0.50	0.6
Commercialization	2	0.47	0.6	0.2	0.33	0.4
Strategic	7	1.63	2.1	0.7	1.17	1.4
Average of data sources by Common Affinity Category	**Frequency**	**Quality**	**Efficiency**	**Information**	**Risk**	**Communication**
Competitiveness	5.67	1.32	1.70	0.57	0.94	1.13
Commercialization	3.33	0.82	1.00	0.33	0.56	0.67
Strategic	7.00	1.28	2.10	0.70	1.17	1.40

World regional providers adopted values in Table 13 from the Trends in Space Commerce that addressed regional launches. [53]

Table 13 - Launch Service Provider by Regions as Percent of Total

Launches by Service Provider Region Yr 2000		
	Launches	**Percent of Total**
U.S.	4	0.15
Europe	12	0.44
Russia	8	0.30
China	0	0.00
Multinational	3	0.11
Total	27	

Multiplying the Percent of Total from Table 13 by that of the Average from Table 12, for each Goal, will result in the values, which populate Table 14. An example would be to derive the U.S. Competitiveness value in Table 1: the value of 0.15, in Table 13 is multiplied by the value of 5.67 in Table 12.

Table 14 - Competitive Pressure Calculation by Region

Competitive Pressures Calculations	Region			
	U.S.	**Europe**	**Russia**	**Multi-national**
Competitiveness	0.84	2.52	1.68	0.63
Commercialization	0.49	1.48	0.99	0.37
Strategic	1.04	3.11	2.07	0.78

Appendix B – Survey Data

Thank you for agreeing to particpate in this survey. It is a critical part of my thesis research addressing issues in the early stages (NASA-phases A/B, DoD-Milestone A)of the product development cycle using the Principles of Lean Thinking (Waste elimination and Value Creation Framework focusing on Value Identification, Value Proposition, and Value Delivery)and those of the Service Management discipline (Servuction and Servqual Models which focuses on service delivery and quality). Also, this survey will address issues surrounding the Government/Contractor relationship and current efforts to make commercilization an integral part of the acquisition strategy. It should take you no more than 15 minutes to complete. Thank you again.

Your time is valuable and that which you've taken to complete this survey is greatly appreciated.

Survey (2)

1. Is your employment experience from the public or private sector?

	Number of Responses	Response Ratio
Public (e.g., U.S.Government, State, etc.)	7	44%
Private	3	19%
Both	6	38%
VIEW Other, Please Specify	0	0%
Total	16	100%

2. How many years of experience do you have?

	Number of Responses	Response Ratio
< 5 Years 1.	0	0%
5 - 10 Years 2.	2	13%
10 - 20 Years 3.	8	50%
> 20 Years 4.	6	38%
Total	16	100%

3. How would you rate your experience level with Government Contracting?

	Number of Responses	Response Ratio
Low	2	13%
Medium	7	44%
High	7	44%
Total	16	100%

4. How important are these parameters to a successful customer/supplier relationship?

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Not Important	2 Important	3 Very Important	4 Not Applicable
1. Procurement Practices employed	6% (1)	19% (3)	69% (11)	6% (1)
2. Congruent Strategies	6% (1)	25% (4)	50% (8)	19% (3)
3. Roles and Responsibilities	6% (1)	19% (3)	69% (11)	6% (1)
4. Market Dynamics	19% (3)	69% (11)	13% (2)	0% (0)
5. Timing- Ability to adapt to changes	0% (0)	19% (3)	75% (12)	6% (1)

5. Indicate the frequency of use of Commercial Procurement Practices in your experience.

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Not at all	2 Infrequent	3 Frequent	4 Often	5 Not Applicable
1. Commercial Spec &: Stds	13% (2)	19% (3)	44% (7)	19% (3)	6% (1)
2. Performance Specifications	13% (2)	31% (5)	25% (4)	31% (5)	0% (0)
3. Streamlined Contract Administration	6% (1)	44% (7)	31% (5)	19% (3)	0% (0)
4. Gov/Contractor Coop & Relationship	13% (2)	44% (7)	31% (5)	13% (2)	0% (0)
5. Commercial-off-the-Shelf/Non-DevelopmentalItems	13% (2)	44% (7)	31% (5)	13% (2)	0% (0)
6. Commercial Warranty	31% (5)	31% (5)	25% (4)	6% (1)	6% (1)
7. Best Value	13% (2)	25% (4)	38% (6)	25% (4)	0% (0)
8. Past Peformance	13% (2)	13% (2)	50% (8)	25% (4)	0% (0)

6	Programs/projects participation.	
#	Response	
1	How many were successful?	90%
	How many were unsuccessful?	10%
2	How many were successful?	~80% of a total >100
	How many were unsuccessful?	~20% of total
3	How many were successful?	23
	How many were unsuccessful?	2
4	How many were successful?	28
	How many were unsuccessful?	2
5	How many were successful?	3
	How many were unsuccessful?	2
6	How many were successful?	
	How many were unsuccessful?	1
7	How many were successful?	It depends on deftn 2
	How many were unsuccessful?	It depends on deftn 2
8	How many were successful?	60%
	How many were unsuccessful?	40%
9	How many were successful?	2
	How many were unsuccessful?	0
10	How many were successful?	2
	How many were unsuccessful?	5
11	How many were successful?	all except 1
	How many were unsuccessful?	1
12	How many were successful?	4-6
	How many were unsuccessful?	1
13	How many were successful?	15
	How many were unsuccessful?	14
14	How many were successful?	7
	How many were unsuccessful?	1
15	How many were successful?	Three
	How many were unsuccessful?	
16	How many were successful?	2
	How many were unsuccessful?	3

7 If successful, why?

#	Response
1	They had strategic value for the customer.
2	(1)Management support and strong individual leading the effort. (2)Clearity in outcomes desired not tasks to accomplish.
3	Excellent pre-contract specification
4	The way I look at things every program I've been on has been successful. For NASA projects we flew hardware that worked successfully. Money and schedule are really not criteria for success at NASA. The Commercial industry we have made money or met cost expectations on all but 1.
5	Adequate resources and time.
6	It was succesful from a development cost perspective. Saved $$s upfront.
7	Realistic Expectations, Well understood requirements, and contingency budget and schedule.
8	HIGH LEVEL IF GOVERNMENT CUSTOMER INVOLVEMENT/ STRUCTURE IN PLACE TO REACT TO ISSUES AS THEY ARRISE
9	Good commercial potential. Contract monitor support through good relationship
10	The projects I worked on were either established projects with clear expectations and roles and responsibilities well-defined or institutional contracts that were award fee or performance based conracts. In either case, none were in the early stages of development, though all underwent changes during the time I worked them.
11	1. Political, NASA and Contractor commitment to succeed 2. Adequate funding to meet clear project objectives 3. Basic R&D technology level adequate to support project development cost, schedule and technical requirements without major R&D breakthroughs. 4. In some cases, such as Apollo Program and commericial oil field product development, there was a total commitment to project success at all levels partly because of a crisis/survival atmosphere. Beating the Russians to the moon and not losing the cold war and oil field tool company survival in extreme industry recession in another situation.
12	Clear purpose, adequate funding, enough time.
13	Early requirements definition, good change control, clear roles and responsibilities, personal relationships and trust-building with internal and external teams.
14	Ownwership was given to the requester to obtain the goods/services necessary to complete the tasks.

8 If unsuccessful, why?

#	Response
1	They had a confusing strategic value to the customer.
2	Lack of leadership inability to adapt quick enough to changing environmental/business conditions
3	Technical failure in high risk ventures
4	During some structural testing we mismeasured the base dimensions and mis-communicated information to the field personnel. This resulted in some gross mistakes during assembly. On a resent project with NASA (I was managing from commercial side) we overspend by 20%. Had some requirement creep and did not watch which personnel were cahrging to the job close enough.
5	Failure to understand internal technical capability at the time a commitment was made to the customer. Failure to deliver reflected poor contractual promises combined with success-mentality that did not staff or budget thinking that anything would go wrong.
6	Poor management; Lack of experience of the performing team
7	It was unsuccessful from a lifecycle support perspective. Production and Spares cost spared no savings.
8	Doing too much with not enough resources (schedule, budget, manpower, etc). Technical challenge much higher than anticipated (rose colored view of these challenges)
9	No commercial potential. Too specialized
10	Type of contract was not conducive to appropriate development activities.
11	I considered the Shuttle upgrades program to be unsuccessful because very few have so far proceeded forward. This had its basis in both technical and budget arenas. The technical reasons were that the performance criteria and desired outcomes were ill-defined or at least not clear. This made them vulnerable when the budget became tight and no clear benefit could be identified, with an accompanying schedule.
12	1. Project cancelled before CDR because of funding constraints and need for Two-Phase Integrated Thermal System (TPITS) flight experiment diminished by Space Station Thermal Control System Design changes
13	Requirements changed radically due to end of Cold War ... system architecture was not robust enough to adapt to a new set of requirements.
14	Too much "red tape" n acquiring the products needed.

9. How would you correlate the following in terms of relative importance to program/project success or failure for the given conditions?

Percentage indicates total respondent ratio and parenthesis indicate actual number.

	1 Meeting performance metrics	2 Cost issues	3 Political Environment changed	4 Overcoming technical challenge	5 Not Applicable
1. Commercial Spec &: Stds	50% (7)	29% (4)	0% (0)	21% (3)	0% (0)
2. Performance Specifications	71% (10)	7% (1)	0% (0)	21% (3)	0% (0)
3. Streamlined Contract Admin	7% (1)	57% (8)	14% (2)	7% (1)	7% (1)
4. Government/Contractor Cooperation & Relationship	7% (1)	21% (3)	43% (6)	21% (3)	0% (0)
5. Commercial-off-the-Shelf/Non-Developmental Items	21% (3)	50% (7)	0% (0)	21% (3)	0% (0)
6. Commercial Warranty	7% (1)	64% (9)	7% (1)	7% (1)	7% (1)
7. Best Value	14% (2)	36% (5)	0% (0)	29% (4)	7% (1)
8. Past Peformance	21% (3)	7% (1)	0% (0)	57% (8)	7% (1)

10. Select top five perceived Risks with commercial procurement practices.

	Number of Responses	Response Ratio
Item performance	11	69%
Fair & Reasonable Price	6	38%
Inconsistent Goals and Objectives	8	50%
Commitment (Leadership)	6	38%
Government/Contractor Culture	7	44%
Commitment (funding)	8	50%
Financial Liability	4	25%
Stability of Requirements	8	50%
Level of Government Participation	2	13%
Agency Pressure	0	0%
Interoperability	4	25%
level of government participation	1	6%
Trust in Contractor	5	31%
Lack of Std Commercial Practices	5	31%
VIEW Other, Please Specify	4	25%

11. Please rate the following relationship traits relative to a successful Program/Project Preparation Phase.

Percentage indicates total respondent ratio and parenthesis indicate actual number.

	1 Not Important	2 Important	3 Very Important	4 Not Applicable
1. Trust	7% (1)	13% (2)	80% (12)	0% (0)
2. Reliability	0% (0)	27% (4)	73% (11)	0% (0)
3. Accuracy of Information	0% (0)	47% (7)	53% (8)	0% (0)
4. Consistency	7% (1)	53% (8)	40% (6)	0% (0)
5. Communication	0% (0)	0% (0)	100% (15)	0% (0)

12. For each phase of the Program/Project Development Life Cycle, rate the degree to which you perceive its products to be tangible or intangible.

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Intangible	2 Mixer of Both Tangible and Intangible	3 Tangible	4 Not Applicable
1. Preparation	25% (4)	44% (7)	31% (5)	0% (0)
2. Planning	13% (2)	56% (9)	31% (5)	0% (0)
3. Execution	0% (0)	25% (4)	75% (12)	0% (0)
4. Adaptation	6% (1)	56% (9)	38% (6)	0% (0)
5. Disposal	6% (1)	38% (6)	56% (9)	0% (0)

13. Please correlate the following to a phase of the Program/Project Life Cycle based on its importance to that phase.

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Preparation	2 Planning	3 Execution	4 Adaptation	5 Disposal
1. Organizational Capability	13% (2)	20% (3)	53% (8)	13% (2)	0% (0)
2. Management Performance	7% (1)	40% (6)	47% (7)	7% (1)	0% (0)
3. Relationship Management(Expectations vs. Perceptions)	27% (4)	20% (3)	33% (5)	20% (3)	0% (0)
4. Product Performance	0% (0)	0% (0)	73% (11)	27% (4)	0% (0)

14. Please correlate the following Service Quality traits to a characteristic of the Lean Value Creation Framework.

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Holistic Perspective	2 Organizational Factors	3 Rerquirements Metrics	4 Tools and Methods	5 Enterprise Relationships	6 Leadership & Management
1. Tangibles	8% (1)	0% (0)	54% (7)	31% (4)	0% (0)	8% (1)
2. Reliability	15% (2)	0% (0)	31% (4)	46% (6)	0% (0)	8% (1)
3. Responsiveness	0% (0)	38% (5)	0% (0)	0% (0)	31% (4)	31% (4)
4. Competence	0% (0)	23% (3)	8% (1)	15% (2)	0% (0)	54% (7)
5. Courtesy	8% (1)	8% (1)	0% (0)	8% (1)	54% (7)	23% (3)
6. Credibility	8% (1)	23% (3)	0% (0)	8% (1)	38% (5)	23% (3)
7. Security	31% (4)	31% (4)	0% (0)	15% (2)	15% (2)	8% (1)
8. Access	8% (1)	62% (8)	0% (0)	15% (2)	8% (1)	8% (1)
9. Communication	8% (1)	38% (5)	0% (0)	0% (0)	46% (6)	8% (1)
10. Understanding	23% (3)	23% (3)	23% (3)	0% (0)	15% (2)	15% (2)

15.	Given the cancellation of the X-33 and X-37 programs or other programs you are familiar with, how would you rate the quality of the Government/Contractor relationship in terms of trust and follow-through.	Number of Responses	Response Ratio
	Poor 1.	3	19%
	Fair 2.	4	25%
	Good 3.	8	50%
	Excellent 4.	1	6%
	Total	16	100%

16.	Based on your experice and perceptions, which classification of program/project Manager characteristics best describe Government Managers:	Number of Responses	Response Ratio
	Heavyweight - Full control, authority and power to effectively manage all aspects of the program/project assigned	5	31%
	Lightweight - Control, authority and power of a few aspects and ineffective in others	4	25%
	VIEW Other, Please Specify	7	44%
	Total	16	100%

16	Based on your experice and perceptions, which classification of program/project Manager characteristics best describe Government Managers:
#	Response
1	vary by the individual on whole manage details and politics more than outcomes and schedule
2	Middleweight - Somewhat full control, authority and power to effectively manage all aspects of the program/project assigned.
3	Hard to rate one or the other. Too many of each within the government depending on the program/project.
4	Unfortunately, it is never that black or white. My experience has been that some managers are heavyweight and some are lightweight, but most are a blend.
5	Early NASA Programs-Apollo/Skylab/Shuttle Gov't Program Mgrs were Heavyweights with minimal turnover; in later programs they have been Lighterweights with high turnover because of political interference with sound project engineering decisions and lack of candor with congressional oversight committees and staffers on projected costs of projects
6	Mediumweight - Control, authority and power of many aspects and ineffective in a few.
7	Varies from project to project and even within elements of a single project.

From: Douglas, Freddie
Sent: Sunday, November 25, 2001 6:26 PM
To: 'adamsbj@sverdrup.com'; 'mlbacon@shellus.com'; 'chamblisstn@navsea.navy.mil'; 'rhonda.c.thompson@msfc.nasa.gov'; 'sdarling@inetdecisions.com'; 'DoerryN@NAVSEA.NAVY.MIL'; 'hal_doiron@hotmail.com'; 'ofiguero@mail.hq.nasa.gov'; Geiger, Dave; 'ramog@aol.com'; 'Pedro.I.Rodriguez@msfc.nasa.gov'; 'mserra@mit.edu'; 'Susan.G.Turner@msfc.nasa.gov'; 'stichcha@pweh.com'; Lightfoot, Robert; Gilbrech, Richard; Carstens, David; 'A.A.Moore@larc.nasa.gov'; 'niemeyer@pweh.com'
Subject: Errata, Thesis survey for Freddie Douglas, III- NASA SDM Fellow

Survey Participant,

You are receiving this email to provide you with errata for the subject survey notice you received earlier this week. The Errata is as follows:

1. Question 10 - disregard the second listing of "level of government participation"
2. Question 15 - X-37 should be X-34.

Thank you for your patience and participating in the survey.

If you have already completed the survey, there is no need to re-take the survey and a I appreciate your quick response.

Thank you again,
Freddie Douglas, III

Survey (3)

1. Is your employment experience from the public or private sector?

	Number of Responses	Response Ratio
Public (e.g., U.S.Government, State, etc.)	3	50%
Private	2	33%
Both	1	17%
VIEW Other, Please Specify	0	0%
Total	6	100%

2. How many years of experience do you have?

	Number of Responses	Response Ratio
< 5 Years 1.	0	0%
5 - 10 Years 2.	1	17%
10 - 20 Years 3.	4	67%
> 20 Years 4.	1	17%
Total	6	100%

3. How would you rate your experience level with Government Contracting?

	Number of Responses	Response Ratio
Low	3	50%
Medium	2	33%
High	1	17%
Total	6	100%

4. How important are these parameters to a successful customer/supplier relationship?

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Not Important	2 Important	3 Very Important	4 Not Applicable
1. Procurement Practices employed	0% (0)	17% (1)	83% (5)	0% (0)
2. Congruent Strategies	0% (0)	67% (4)	33% (2)	0% (0)
3. Roles and Responsibilities	0% (0)	33% (2)	67% (4)	0% (0)
4. Market Dynamics	17% (1)	50% (3)	33% (2)	0% (0)
5. Timing- Ability to adapt to changes	0% (0)	17% (1)	83% (5)	0% (0)

5. Indicate the frequency of use of Commercial Procurement Practices in your experience.

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Not at all	2 Infrequent	3 Frequent	4 Often	5 Not Applicable
1. Commercial Spec & Stds	0% (0)	67% (4)	0% (0)	33% (2)	0% (0)
2. Performance Specifications	0% (0)	0% (0)	33% (2)	67% (4)	0% (0)
3. Streamlined Contract Administration	17% (1)	17% (1)	50% (3)	17% (1)	0% (0)
4. Gov/Contractor Coop & Relationship	17% (1)	50% (3)	0% (0)	17% (1)	17% (1)
5. Commercial-off-the-Shelf/Non-DevelopmentalItems	17% (1)	0% (0)	50% (3)	33% (2)	0% (0)
6. Commercial Warranty	33% (2)	33% (2)	0% (0)	33% (2)	0% (0)
7. Best Value	17% (1)	33% (2)	17% (1)	33% (2)	0% (0)
8. Past Peformance	17% (1)	33% (2)	33% (2)	17% (1)	0% (0)

6 Programs/projects participation.

#	Response
1	How many were successful? 5 How many were unsuccessful? 0
2	How many were successful? 25 How many were unsuccessful? 22
3	How many were successful? 5 How many were unsuccessful? 4
4	How many were successful? 100% How many were unsuccessful?
5	How many were successful? 3 How many were unsuccessful? 8
6	How many were successful? all but one How many were unsuccessful? 1

7 If successful, why?

#	Response
1	Good planning upfront, and expectations well defined.
2	Work was either performed in-house, or with close coordination/cooperation/teaming with contractor.
3	All products were launched into the market place - however, they all did not meet their original schedule. Success attributed to tight monitoring of key deliverables.
4	Early coordination with vendors (detailed specifications). Good team make-up with a reasonable schedule (deliverables). Regular interaction with contractors to ensure on-time delivery of components/parts.
5	sufficient resources and willingness to adapt content/budget/resources to evolving nature of aerospace development task

8 If unsuccessful, why?

#	Response
1	Did not understand expectations or did not follow plan.
2	Project requirements not clearly stated or understood. No cooperation/teaming with contractor. Politics of inter-agency and international projects.
3	This is typical in a research environment. Many times there is not a specific application identified for new technology. Project cancellation.
4	poor program definition and lack of advocacy

9. How would you correlate the following in terms of relative importance to program/project success or failure for the given conditions?

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Meeting performance metrics	2 Cost issues	3 Political Environment changed	4 Overcoming technical challenge	5 Not Applicable
1. Commercial Spec &: Stds	50% (3)	17% (1)	0% (0)	33% (2)	0% (0)
2. Performance Specifications	33% (2)	33% (2)	0% (0)	33% (2)	0% (0)
3. Streamlined Contract Admin	0% (0)	67% (4)	0% (0)	0% (0)	33% (2)
4. Government/Contractor Cooperation & Relationship	17% (1)	33% (2)	50% (3)	0% (0)	0% (0)
5. Commercial-off-the-Shelf/Non-Developmental Items	50% (3)	33% (2)	0% (0)	0% (0)	17% (1)
6. Commercial Warranty	33% (2)	33% (2)	0% (0)	0% (0)	33% (2)
7. Best Value	67% (4)	33% (2)	0% (0)	0% (0)	0% (0)
8. Past Peformance	50% (3)	17% (1)	0% (0)	17% (1)	17% (1)

10. Select top five perceived Risks with commercial procurement practices.	Number of Responses	Response Ratio
Item performance	2	33%
Fair & Reasonable Price	2	33%
Inconsistent Goals and Objectives	4	67%
Commitment (Leadership)	1	17%
Government/Contractor Culture	1	17%
Commitment (funding)	1	17%
Financial Liability	1	17%
Stability of Requirements	5	83%
Level of Government Participation	1	17%
Agency Pressure	0	0%
Interoperability	2	33%
Trust in Contractor	1	17%
Lack of Std Commercial Practices	4	67%
VIEW Other, Please Specify	1	17%

10 Select top five perceived Risks with commercial procurement practices.	
#	Response
1	no experience with commercial procurement practices

11. Please rate the following relationship traits relative to a successful Program/Project Preparation Phase.				
Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Not Important	2 Important	3 Very Important	4 Not Applicable
1. Trust	0% (0)	17% (1)	83% (5)	0% (0)
2. Reliability	17% (1)	33% (2)	50% (3)	0% (0)
3. Accuracy of Information	0% (0)	17% (1)	83% (5)	0% (0)
4. Consistency	0% (0)	33% (2)	50% (3)	0% (0)
5. Communication	0% (0)	0% (0)	83% (5)	17% (1)

12. For each phase of the Program/Project Development Life Cycle, rate the degree to which you perceive its products to be tangible or intangible.

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Intangible	2 Mixer of Both Tangible and Intangible	3 Tangible	4 Not Applicable
1. Preparation	50% (3)	33% (2)	17% (1)	0% (0)
2. Planning	33% (2)	50% (3)	17% (1)	0% (0)
3. Execution	0% (0)	67% (4)	33% (2)	0% (0)
4. Adaptation	17% (1)	33% (2)	50% (3)	0% (0)
5. Disposal	0% (0)	50% (3)	50% (3)	0% (0)

13. Please correlate the following to a phase of the Program/Project Life Cycle based on its importance to that phase.

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Preparation	2 Planning	3 Execution	4 Adaptation	5 Disposal
1. Organizational Capability	33% (2)	33% (2)	33% (2)	0% (0)	0% (0)
2. Management Performance	0% (0)	50% (3)	33% (2)	17% (1)	0% (0)
3. Relationship Management(Expectations vs. Perceptions)	0% (0)	0% (0)	83% (5)	17% (1)	0% (0)
4. Product Performance	0% (0)	0% (0)	67% (4)	33% (2)	0% (0)

14. Please correlate the following Service Quality traits to a characteristic of the Lean Value Creation Framework.

Percentage indicates total respondent ratio and parenthesis indicate actual number.	1 Holistic Perspective	2 Organizational Factors	3 Rerquirements Metrics	4 Tools and Methods	5 Enterprise Relationships	6 Leadership & Management
1. Tangibles	0% (0)	17% (1)	17% (1)	50% (3)	0% (0)	0% (0)
2. Reliability	0% (0)	0% (0)	33% (2)	50% (3)	17% (1)	0% (0)
3. Responsiveness	0% (0)	17% (1)	0% (0)	0% (0)	50% (3)	33% (2)
4. Competence	0% (0)	0% (0)	33% (2)	17% (1)	0% (0)	50% (3)
5. Courtesy	0% (0)	0% (0)	0% (0)	0% (0)	67% (4)	17% (1)
6. Credibility	0% (0)	0% (0)	0% (0)	17% (1)	0% (0)	83% (5)
7. Security	50% (3)	17% (1)	0% (0)	17% (1)	17% (1)	0% (0)
8. Access	17% (1)	50% (3)	0% (0)	0% (0)	17% (1)	17% (1)
9. Communication	0% (0)	0% (0)	0% (0)	0% (0)	33% (2)	67% (4)
10. Understanding	17% (1)	17% (1)	0% (0)	0% (0)	0% (0)	67% (4)

15.	Given the cancellation of the X-33 and X-34 programs or other programs you are familiar with, how would you rate the quality of the Government/Contractor relationship in terms of trust and follow-through.	Number of Responses	Response Ratio
Poor 1.		2	40%
Fair 2.		3	60%
Good 3.		0	0%
Excellent 4.		0	0%
	Total	5	100%

16.	Based on your experice and perceptions, which classification of program/project Manager characteristics best describe Government Managers:	Number of Responses	Response Ratio
Heavyweight - Full control, authority and power to effectively manage all aspects of the program/project assigned		1	17%
Lightweight - Control, authority and power of a few aspects and ineffective in others		3	50%
VIEW Other, Please Specify		2	33%
	Total	6	100%

16	Based on your experice and perceptions, which classification of program/project Manager characteristics best describe Government Managers:
#	Response
1	Focused on personal agendas
2	No experience with gov't contracting

Appendix C – Quality Function Deployment Analysis

Figure 48 reflects the results of the QFD analysis using data from the preceding Tables and Figures in Appendix B. The QFD reflects the elements of the house of quality through the "what versus house" section that maps the goals against the implementation approach. It also includes opportunities to identify areas where conflicts might exist within the implementation approach. The diagram also includes an attempt to relate product development values to the goals derived from the data sources indications of competitive Pressures.

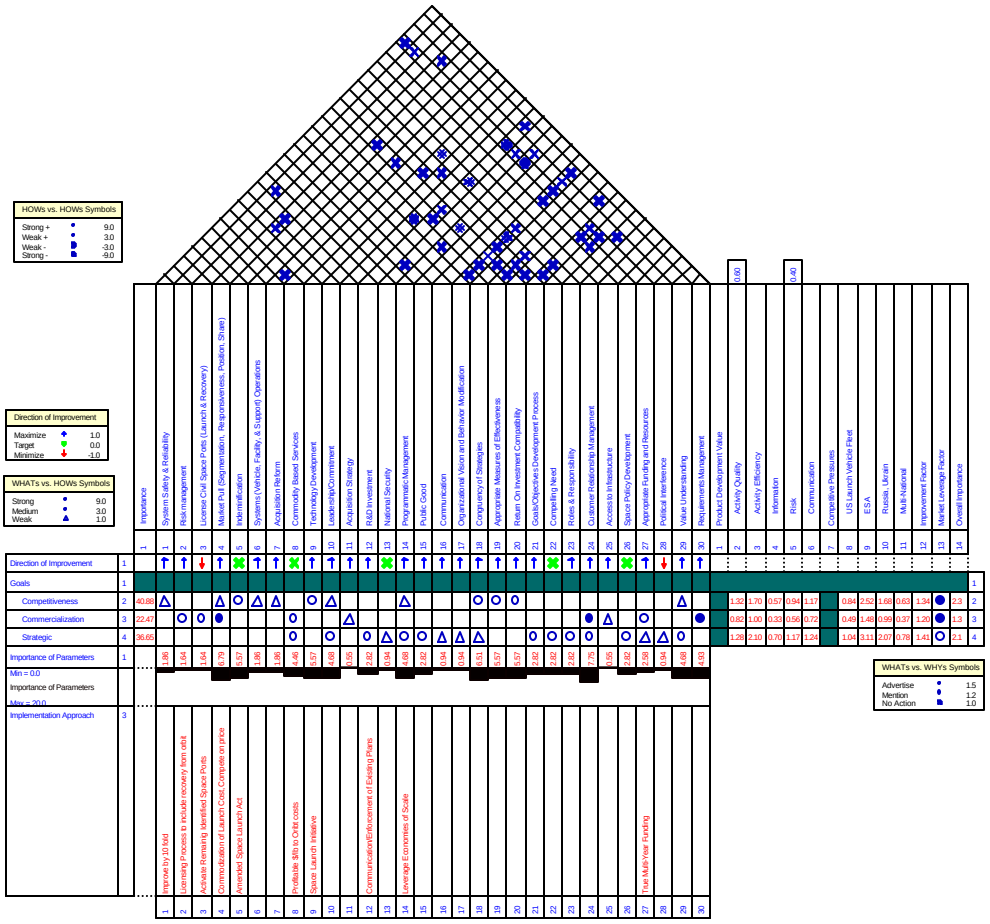

Figure 48 - Access-to-space QFD

Figure 49 reflects the "How versus How" sections of the quality house where potential conflicts between the implementation elements (elements of the Affinity Diagram) are identified. Bold "xs" are considered strong conflicts, which require significant attention to overcome any negative influences that

could lead to the effort being unsuccessful. All others are considered weak and can be overcome relatively easily with attention to planning.

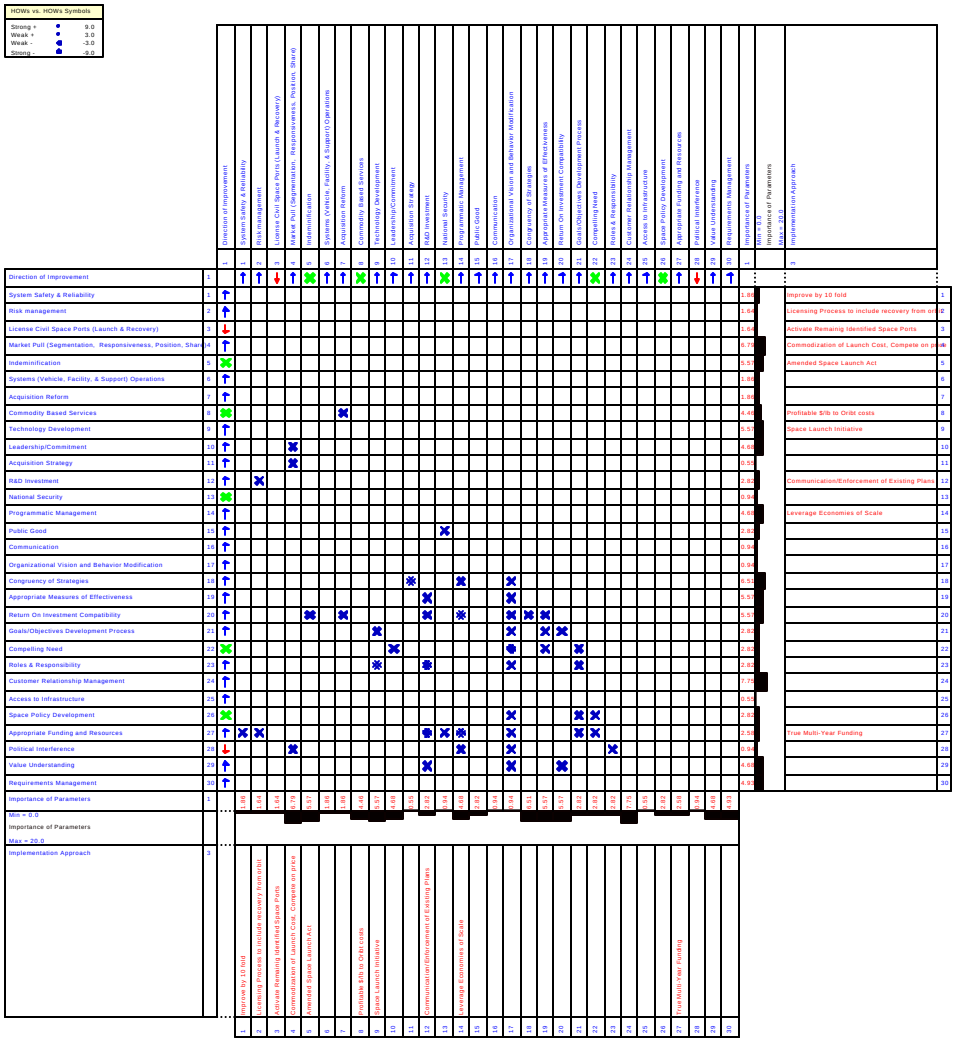

Figure 49 - Access-to-space How vs How Conflict Matrix

Appendix D - Framework Mapping

Using P/P Preparation Phase issues, traits, and behaviors derived from the data and information gathered as a part of this thesis, and corresponding Preparation Phase Issues are mapped to their representative Servqual Conceptual Factors. These are used to further corroborate the thesis that the P/P Phase can be managed for success using the management of services perspective. Each Gap is mapped as shown in Tables 15, 16, 17, and 18.

Table 15 – Gap - 1 Customer Expectations

Servqual Conceptual Factors [11]		**Derived Program/Project Preparation Phase Issues**
Factor and Definition	**Specific Illustrative Issues**	
Marketing Research Orientation: Extent to which managers make an effort to understand customers' needs and expectations through formal and informal information-gathering activities	• Is research conducted regularly to generate information about what customers want? • Does the marketing research a company conducts focus on quality of service delivered by it? • Do managers understand and utilize the research findings? • Do managers mingle with customers to learn what is on their minds?	**Goals and Objective Setting:** • Roles and Responsibilities • Congruent Strategies o National o Strategic o Tactical o Commercial o Architectural • Consensus on Measures of Effectiveness • Decision Making Process and Levels
Upward Communication: Extent to which top management seeks, stimulates, and facilitates the flow of information from employees at lower levels	• Do managers encourage suggestions from customers contact personnel concerning quality of service? • Are there formal or informal opportunities for customer contact personnel to communicate with management? • How frequent do managers have face-to-face contact with customer contact personnel?	**Customer/Stakeholder Communication:** • Congress to Agency, Government to Private Sector and Private Sector to Government • Government Participation Level o Oversight o Insight o Partner • Stakeholder Influence/Interaction • Decision Making Process and Levels
Levels of Management: Number of managerial levels between the topmost and bottommost positions.	• Do too many managerial levels separate top managers from those responsible for dealing with and serving customers?	**Influence Opportunities:** • Too many opportunities for stakeholder influence • All aspects of the Political Process o Congressional Inquiry o Implementing Agency Culture

		○ Public Forums • End user is removed from the process

Table 16 - Gap - 2 Service Standards

Servqual Conceptual Factors [11]		**Derived Program/Project Preparation Phase Issues**
Factor and Definition	**Specific Illustrative Issues**	
Management Commitment to Service Quality: Extent to which management views service quality as a key strategic goal.	• Are resources committed to departments to improve service quality? • Do internal programs exist for improving the quality of service to customers? • Are managers who improve the quality of service to customers more likely to be rewarded than other managers? • Does the company emphasize its sales goals as much as or more than it emphasizes serving customers? • Are upper and middle managers committed to providing quality service to their customers?	**Commit to and Stability of Purpose:** • Strategic Perspective • Funding • Schedule • Goals, Objectives and Requirements
Perception of Feasibility: Extent to which managers believe that customer expectations can be met.	• Does the company have the necessary capabilities to meet customer requirements for service? • Can customer expectations be met without hindering financial performance? • Do existing operations systems enable customer expectations to be met? • Are resources and personnel available to deliver the level of service that customers demand? • Does management change existing policies and procedures to meet the needs of customers?	**Feasibility and Risk:** • Analysis. Interpretation and Decision • Management Process ○ MOE ○ Decision Process • System Performance • Operations Concept • Financial • Technology • Risk ○ Financial ○ Performance ○ Technology ○ Environment ▪ Development ▪ Operations
Task Standardization: Extent to which hard and soft technology are used to standardize service tasks.	• Is automation used to achieve consistency in serving customers? • Are programs in place to improve operating procedures so that consistent service is provided?	**Customer/Stakeholder Integration:** Communication • Mechanism/Media • Testimony • Reports by third parties (OIG, OMB, GAO) [14] • Web sites and portals
Goal-Setting:	• Is there a formal process for	**Measures of Effectiveness:**

Extent to which service quality goals are based on customer standards and expectations rather than company standards.	setting quality of service goals for employees? • Does the company have clear goals about what it wants to accomplish? • Does the company measure its performance in meeting its service quality goals? • Are service quality goals based on customer-oriented standards rather than company-oriented standards?	• Management Performance • System Performance • Operating and Development Environment dynamics • Balanced Score Card implementation

Table 17 - Gap - 3 Service Performance

Servqual Conceptual Factors [11]		**Derived Program/Project Preparation Phase Issues**
Factor and Definition	**Specific Illustrative Issues**	
Role Ambiguity: Extent to which employees are uncertain about what managers or supervisors expect from them and how to satisfy those expectations.	• Does management provide accurate information to employees concerning job instruction, company policy and procedures, and performance assessment? • Do employees understand the products and services offered by the company? • Are employees able to keep up with changes that affect their jobs? • Are employees trained to interact effectively with customers? • How often does management communicate company goals and expectations to employees? • Do employees understand what managers expect from them and how to satisfy those expectations?	**Role and Responsibility:** • Sort out and Recognize Customer from Stakeholder o Customer – General Public o Stakeholder – Congress/Agency o Supplier – Agency/Private Sector o Supply Chain – Private Sector/Agency • Clear, Stable & Complete Goals, Objectives and Requirements • Multi-Agency overlapping responsibility
Role Conflict: Extent to which employees perceive that they cannot satisfy all the demands of all the individuals (internal and external customers) they must serve.	• Do customers and managers have the same expectations of employees? • How often do customer-contact employees have to depend on other support services employees to provide quality service to customers? • Do employees have more work to do than they have time to do it? • Does the number of demands in employees' jobs make it difficult to effectively serve customers?	**Conflicting Mandates:** Laws, regulations, and policies direct employee behavior • Government Performance and Reporting Act • Acquisition Reform Act • Space Policy • Space Launch Act • Multi-Agency Management • Technology and R&D Investment strategies and implementation

	• Do too many customers want service at the same time? • Do employees cross-sell services to customers in situations where it is inappropriate?	
Employee-Job Fit: The match between the skill of employees and their jobs.	• Do employees believe that they are able to perform their jobs well? • Does the company hire people who are qualified to do their jobs? • Does management devote sufficient time and resources to the hiring and selection of employees?	**Management:** • Employee Training • Strategy for Job Selection • Qualifications • Systems used as part of job
Technology-Job Fit: The appropriateness of the tools and technology that employees used to perform their jobs.	• Are employees given the tools and equipment needed to perform their jobs well? • How often does equipment fail to operate?	**Information and Operational Technology:** • Process Management • Knowledge Management • Collaborative Development Environments • Decision Support Systems • Employee Training
Supervisory Control Systems: The appropriateness of the evaluation and reward systems in the company.	• Do employees know what aspects of their jobs will be stressed most in performance evaluations? • Are employees evaluated on how well they interact with customers? • Are employees who do the best job serving customers more likely to be rewarded then other employees? • Do employees who make a special effort to serve customers receive increased financial rewards, career advancement, and/or recognition? • Do employees feel appreciated for their contributions?	**Stakeholder Priorities Fluctuations:** • Occurrence of Greater Social Event • Environmental Influences • Goals and Objectives out of synchronization
Perceived Control: Extent to which employees perceive that they can act flexibly rather than by rote in problem situations encountered in providing services.	• Do employees spend time in their jobs trying to resolve problems over which they have little control? • Are employees given the freedom to make individual decisions to satisfy customers' needs? • Are employees required to get approval from another department before delivering service to customers?	**Management Approach:** • Heavyweight Management • Lightweight Management • Functional vs. P/P Management

Teamwork: Extent to which employees and managers pull together for a common goal.	• Do employees and managers contribute to a team effort in servicing customers? • Do support services employees provide good service to customer-contact personnel? • Are employees personally involved and committed to the company? • Do customer-contact employees cooperate more than they compete with other employees in the company? • Are employees encouraged to work together to provided quality service to customers?	**Development Team Structure:** • Tiger Team • Integrated Product Team

Table 18 - Gap - 4 Promises Do No Match Delivery

Servqual Conceptual Factors [11]		**Derived Program/Project Preparation Phase Issues**
Factor and Definition	**Specific Illustrative Issues**	
Horizontal Communication: Extent to which communication occurs both within and between different department of a company.	• Do customer contact personnel have input in advertising planning and execution? • Are customer contact personnel aware of external communications to customers before they occur? • Does the sales force interact with customer contact personnel to discuss the level of service that can be delivered to customers? • Are the policies and procedures for serving customers consistent across departments and branches?	**Risk Management:** • Communication up and down organization • Risk Planning and mitigation • Timely external communication
Propensity to Over-promise: Extent to which a company's external communications do not accurately reflect what customers receive in the service encounter.	• Is there increasing pressure inside the company to generate new business? • Do competitors over-promise to gain new customers?	**Better to Ask Forgiveness than Permission:** • Over sell system performance • Under predict cost • Over estimate technology readiness • Over Predict commercialization